Cat. No. W469-E1-07

SYSMAC
CX-Programmer Ver. 9.□
CXONE-AL□□C-V4/AL□□D-V4

Operation Manual
SFC Programming

OMRON

SYSMAC

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Operation Manual

SFC Programming

Revised October 2010

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About this Manual:

SFC programming functions have been added to the CX-Programmer. This manual describes the specifications of the SFC language, and the CX-Programmer operations related to the SFC programming functions. For operations not related to SFC programming, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

For details on operations related to function blocks and structured text, refer to the *CX-Programmer Operation Manual Function Blocks/Structured Texts* (Cat. No. W447).

Intended Audience

This manual is intended for the following personnel, who must also have knowledge of electrical systems (an electrical engineer or the equivalent).

- Personnel in charge of installing FA systems.
- Personnel in charge of designing FA systems.
- Personnel in charge of managing FA systems and facilities.

⚠Caution Please read this manual and related manuals carefully and be sure you understand the information provided before attempting to install or operate the CX-Programmer, the CJ2 Units with unit version 1.0 or later, or the CS1-H, CJ1-H, or CJ1M CPU Units with unit version 4.0 or later. Be sure to read the precautions provided in the following section.

Read and Understand this Manual

Please read and understand this manual before using the product. Please consult your OMRON representative if you have any questions or comments.

Warranty and Limitations of Liability

WARRANTY
(1) The warranty period for the Software is one year from either the date of purchase or the date on which the Software is delivered to the specified location. **(2) If the User discovers a defect in the Software (i.e., substantial non-conformity with the manual), and returns it to OMRON within the above warranty period, OMRON will replace the Software without charge by offering media or downloading services from the Internet. And if the User discovers a defect in the media which is attributable to OMRON and returns the Software to OMRON within the above warranty period, OMRON will replace the defective media without charge. If OMRON is unable to replace the defective media or correct the Software, the liability of OMRON and the User's remedy shall be limited to a refund of the license fee paid to OMRON for the Software.**

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(1) THE ABOVE WARRANTY SHALL CONSTITUTE THE USER'S SOLE AND EXCLUSIVE REMEDIES AGAINST OMRON AND THERE ARE NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT WILL OMRON BE LIABLE FOR ANY LOST PROFITS OR OTHER INDIRECT, INCIDENTAL, SPECIAL, OR CONSEQUENTIAL DAMAGES ARISING OUT OF USE OF THE SOFTWARE. **(2) OMRON SHALL ASSUME NO LIABILITY FOR DEFECTS IN THE SOFTWARE BASED ON MODIFICATION OR ALTERATION OF THE SOFTWARE BY THE USER OR ANY THIRD PARTY.** **(3) OMRON SHALL ASSUME NO LIABILITY FOR SOFTWARE DEVELOPED BY THE USER OR ANY THIRD PARTY BASED ON THE SOFTWARE OR ANY CONSEQUENCE THEREOF.**

Application Considerations

SUITABILITY FOR USE
THE USER SHALL NOT USE THE SOFTWARE FOR A PURPOSE THAT IS NOT DESCRIBED IN THE ATTACHED USER MANUAL.

Disclaimers

CHANGE IN SPECIFICATIONS
The software specifications and accessories may be changed at any time based on improvements or for other reasons.

EXTENT OF SERVICE
The license fee of the Software does not include service costs, such as dispatching technical staff.

ERRORS AND OMISSIONS
The information in this manual has been carefully checked and is believed to be accurate; however, no responsibility is assumed for clerical, typographical, or proofreading errors, or omissions.

Manuals Related to the CX-Programmer

Name	Cat. No.	Contents
CXONE-AL□□C-V4/AL□□D-V4 CX-Programmer Operation Manual: SFC	W469 (this manual)	Explains how to use the SFC programming functions. For explanations of other shared CX-Programmer functions, refer to the *CX-Programmer Operation Manual* (W446).
CXONE-AL□□C-V4/AL□□D-V4 CX-Programmer Operation Manual Function Blocks/Structured Texts	W447	Describes the function block functions and structured text programming functions that can be used with the CX-Programmer. For details on other CX-Programmer functions, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).
CXONE-AL□□C-V4/AL□□D-V4 CX-Programmer Operation Manual	W446	Describes the general CX-Programmer operations that are not specifically related to SFC programming, function block functions, and structured text programming functions.
CXONE-AL□□C-V4/AL□□D-V4 CX-Integrator Operation Manual	W464	Describes operating procedures for the CX-Integrator Network Configuration Tool for CS-, CJ-, CP-, and NSJ-series Controllers.
CXONE-AL□□C-V4/AL□□D-V4 CX-One Setup Manual	W463	Installation and overview of CX-One FA Integrated Tool Package.

Manuals Related to the CJ2, CS1-H, CJ1-H, CJ1M PLCs

Name	Cat. No.	Contents
SYSMAC CJ Series **CJ2H-CPU6□-EIP, CJ2H-CPU6□** **CJ2M-CPU1□, CJ2M-CPU3□** **Programmable Controllers** **Hardware User's Manual**	W472	Provides an outline of and describes the design, installation, maintenance, and other basic operations for the CJ-series CJ2 CPU Units. The following information is included: Overview and features System configuration Installation and wiring Troubleshooting Use this manual together with the W473.
SYSMAC CJ Series **CJ2H-CPU6□-EIP, CJ2H-CPU6□** **CJ2M-CPU1□, CJ2M-CPU3□** **Programmable Controllers** **Software User's Manual**	W473	Describes programming and other methods to use the functions of the CJ2 CPU Units. The following information is included: CPU Unit operation Internal memory areas Programming Tasks CPU Unit built-in functions Use this manual together with the W472.
SYSMAC CS/CJ Series **CS1G/H-CPU□□-EV1, CS1G/H-CPU□□H,** **CS1D-CPU□□H, CS1D-CPU□□S,** **CJ2H-CPU6□-EIP, CJ2H-CPU6□,** **CJ2M-CPU1□, CJ2M-CPU3□** **CJ1H-CPU□□H-R** **CJ1G-CPU□□, CJ1G/H-CPU□□H,** **CJ1G-CPU□□P, CJ1M-CPU□□** **SYSMAC One NSJ Series** **NSJ□-□□□□ (B)-G5D** **NSJ□-□□□□ (B)-M3D** **Programmable Controllers** **Instructions Reference Manual**	W474	Describes the ladder diagram programming instructions supported by CS/CJ-series or NSJ-series PLCs. When programming, use this manual together with the *Operation Manual or Hardware User's Manual* (CS1: W339, CJ1: W393,or CJ2:W472) and *Programming Manual or Software User's Manual* (CS1/CJ1:W394 or CJ2:W473).
SYSMAC CS Series **CS1G/H-CPU□□-EV1, CS1G/H-CPU□□H** **Programmable Controllers** **Operation Manual**	W339	Provides an outline of and describes the design, installation, maintenance, and other basic operations for the CS-series PLCs. The following information is included: An overview and features The system configuration Installation and wiring I/O memory allocation Troubleshooting Use this manual together with the W394.
SYSMAC CJ Series **CJ1G-CPU□□, CJ1G/H-CPU□□H,** **CJ1G-CPU□□ P, CJ1M-CPU□□** **Programmable Controllers** **Operation Manual**	W393	Provides an outline of and describes the design, installation, maintenance, and other basic operations for the CJ-series PLCs. The following information is included: An overview and features The system configuration Installation and wiring I/O memory allocation Troubleshooting Use this manual together with the W394.
SYSMAC CS/CJ Series **CS1G/H-CPU□□-EV1, CS1G/H-CPU□□H,** **CJ1G-CPU□□, CJ1G/H-CPU□□H,** **CJ1G-CPU□□P, CJ1M-CPU□□** **Programmable Controllers** **Programming Manual**	W394	Describes programming and other methods to use the functions of the CS/CJ-series PLCs. The following information is included: Programming Tasks File memory Other functions Use this manual together with the W339 or W393.

Name	Cat. No.	Contents
SYSMAC CS/CJ Series CS1G/H-CPU□□ -EV1, CS1G/H-CPU□□H, CJ1G-CPU□□, CJ1G/H-CPU□□H, CJ1G-CPU□□P, CJ1M-CPU□□ Programmable Controllers Instructions Reference Manual	W340	Describes the ladder diagram programming instructions supported by CS/CJ-series PLCs. When programming, use this manual together with the *Operation Manual* (CS1: W339 or CJ1: W393) and *Programming Manual* (Cat. No. W394).
SYSMAC CS/CJ Series CS1G/H-CPU□□-EV1, CS1G/H-CPU□□H, CS1W-SCB21-V1/41-V1, CS1W-SCU21/41, CJ2H-CPU6□-EIP, CJ2H-CPU6□, CJ2M-CPU1□, CJ2M-CPU3□ CJ1G-CPU□□, CJ1G/H-CPU□□H, CJ1G-CPU□□P, CJ1M-CPU□□, CJ1W-SCU21-V1/41-V1 Communications Commands Reference Manual	W342	Describes the communications commands that can be addressed to CS/CJ-series CPU Units. The following information is included: C-series (Host Link) commands FINS commands **Note:** This manual describes commands that can be sent to the CPU Unit without regard for the communications path, which can be through a serial communications port on the CPU Unit, a communications port on a Serial Communications Unit/Board, or a port on any other Communications Unit.

Notice:

OMRON products are manufactured for use according to proper procedures by a qualified operator and only for the purposes described in this manual.

The following conventions are used to indicate and classify precautions in this manual. Always heed the information provided with them. Failure to heed precautions can result in injury to people or damage to property.

⚠DANGER	Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. Additionally, there may be severe property damage.
⚠WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury. Additionally, there may be severe property damage.
⚠Caution	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury, or property damage.

⚠WARNING

Confirm safety thoroughly in advance when using the CX-Programmer to transfer any I/O memory data to the actual PLC. Changes to the PLC's I/O memory may result in unexpected operation of devices connected to Output Units, regardless of the PLC's operating mode.
The following functions require particular caution when using the CX-Programmer to transfer data to the CPU Unit's I/O memory.

- Transferring data from the CX-Programmer to the CPU Unit's CIO Area (with the PLC Memory Window function)
- Transferring data from a Memory Card or EM file memory to the CPU Unit's CIO Area (with the Memory Card Window function)

⚠Caution

Confirm safety at the destination node before transferring a program to another node or changing contents of the I/O memory area. Doing either of these without confirming safety may result in injury.

⚠Caution

Execute online editing only after confirming that no adverse effects will be caused by extending the cycle time. Otherwise, the input signals may not be readable.

Application Precautions

Observe the following precautions when using the CX-Programmer's SFC functions.

- As a rule, the outputs of actions are reset when a step is changed from active status to inactive status. When changing an output's hold/reset setting, change the initial setting or add reset processing as necessary. When making changes, verify the operational timing of actions in the preceding and following steps.

  Note: Refer to *1-5-1 Holding or Resetting an Action's Outputs* and *1-5-2 Action Program Precautions* for details.
- Observe the following precautions before starting the CX-Programmer.
  - Exit all applications not directly related to the CX-Programmer. Particularly exit any software such as screen savers, virus checkers, E-mail or other communications software, and schedulers or other applications that start up periodically or automatically.
  - Disable sharing hard disks, printers, or other devices with other computers on any network.
  - With some notebook computers, the RS-232C port is allocated to a modem or an infrared line by default. Following the instructions in documentation for your computer and enable using the RS-232C port as a normal serial port.
  - With some notebook computers, the default settings for saving energy do not supply the rated power to the RS-232C port. There may be both Windows settings for saving energy, as well as setting for specific computer utilities and the BIOS. Following the instructions in documentation for your computer, disable all energy saving settings.
- Do not turn OFF the power supply to the PLC or disconnect the connecting cable while the CX-Programmer is online with the PLC. The computer may malfunction.
- Confirm that no adverse effects will occur in the system before attempting any of the following. Not doing so may result in an unexpected operation.
  - Changing the operating mode of the PLC.
  - Force-setting/force-resetting any bit in memory.
  - Changing the present value of any word or any set value in memory.
- Check the user program for proper execution before actually running it on the Unit. Not checking the program may result in an unexpected operation.
- When online editing is performed, the user program and parameter area data in CJ2, CS1-H, CJ1-H, CJ1M, and CP1H CPU Units is backed up in the built-in flash memory. The BKUP indicator will light on the front of the CPU Unit when the backup operation is in progress. Do not turn OFF the power supply to the CPU Unit when the BKUP indicator is lit. The data will not be backed up if power is turned OFF. To display the status of writing to flash memory on the CX-Programmer, select Display dialog to show PLC Memory Backup Status in the PLC properties and then select Windows – PLC Memory Backup Status from the View Menu.

Instructions for Use

Do not turn OFF the power supply to the computer while installing or uninstalling the CX-Programmer. The data in a computer may be corrupted.

Description of Programmable Controllers

The abbreviation “PLC” means Programmable Controller. “PC” is used, however, in some Programming Device displays to mean Programmable Controller.

SECTION 1
Overview

1-1 SFC Overview 2
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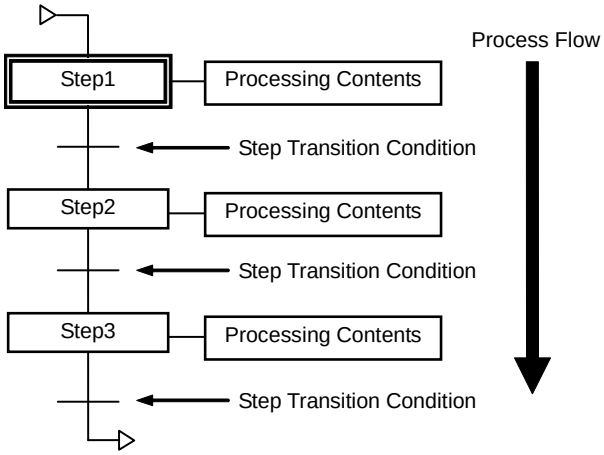
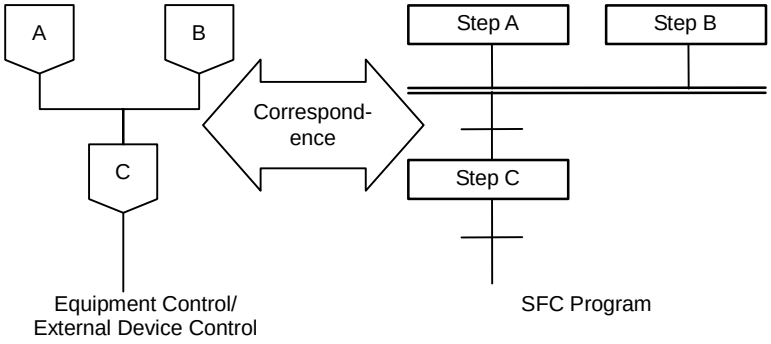
1-1 SFC Overview

1-1-1 SFC Overview

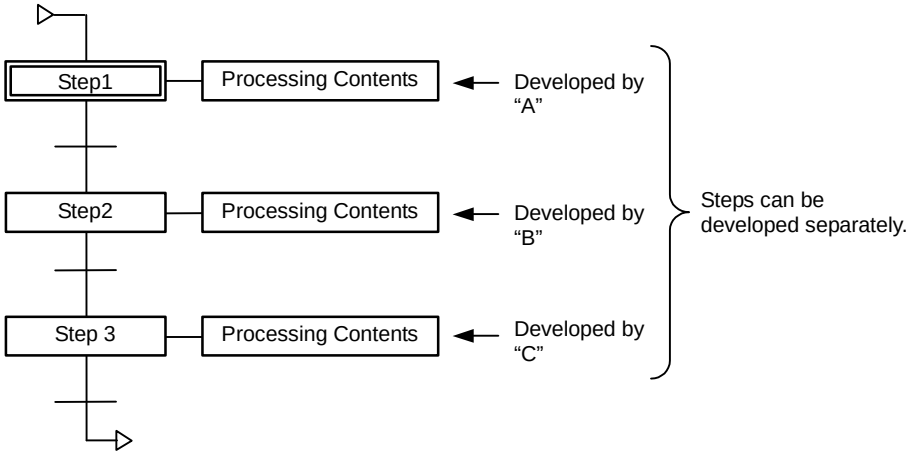
The SFC (Sequential Function Chart) language is a graphical programming language developed to facilitate the description of step progression programs, which mainly control sequential processes.
SFC, with its graphical representation of step flow and with description of the conditions for step progression and the actions in each step, allows users to program the control of sequential processes.



SFC offers the following advantages.
Since step flow and program control correspond, even third-party programmers can easily understand the program, as a whole. This reduces the program debugging and maintenance workload.



Programs can be created separately for each step, without the need to consider complicated requirement exchanges between steps. In other words, each step can be programmed separately, by a different developer, making program development simpler and more efficient.



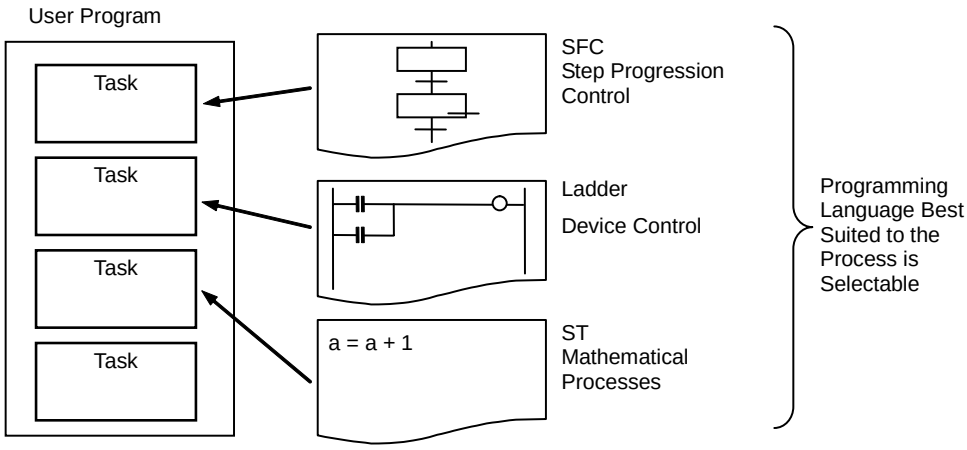
Programs are independently completed for each step, and are therefore simple to reuse.
Processing is performed on a per step basis, giving process time, only to active steps, and not to inactive steps, allowing the CPU unit cycle time to be shortened.

1-1-2 CX-Programmer Features

The CX-Programmer Support Software is equipped with an SFC editor, and can be used to create, monitor, and debug SFC programs for CS/CJ-series and CJ2-series PLCs. The CX-Programmer supports SFC language in addition to conventional ladder and structured text (ST) programming languages.
With desirable features, such as the user interface, carried over from the earlier series, and with the added SFC programming function, the CX-Programmer provides a programming environment that can take full advantage of the SFC language's features.

Combining SFC, Ladder, and ST for User Programs

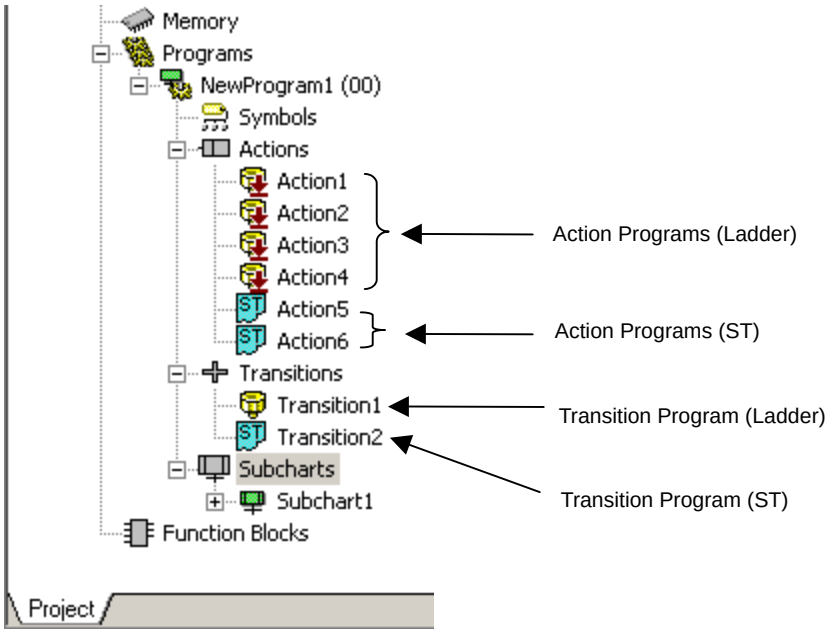
Each program allocated to a task can be coded as an arbitrary combination of SFC, ladder, and ST. Hence, the language best suited to each process can be utilized (e.g. SFC for step progression, ladder for device control, and ST for mathematical processes).
The common functions of CX-Programmer are still available to use, regardless of the language used.



Ladder and ST as Part of SFC Programs

The step actions and transition conditions within an SFC program can be coded in either ladder or ST.

The step actions and transition conditions coded in ladder or ST are registered in an SFC program as action programs and transition programs.

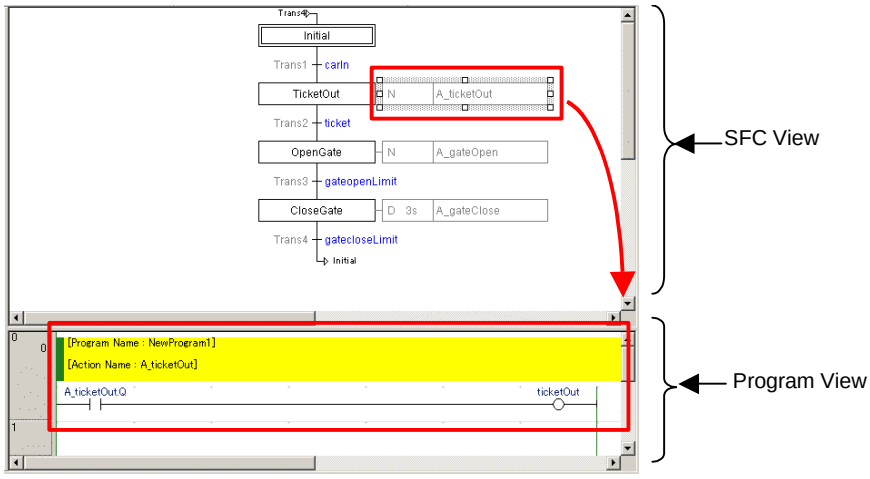


Simultaneous Display/Editing of SFC Charts and Action/Transition Programs

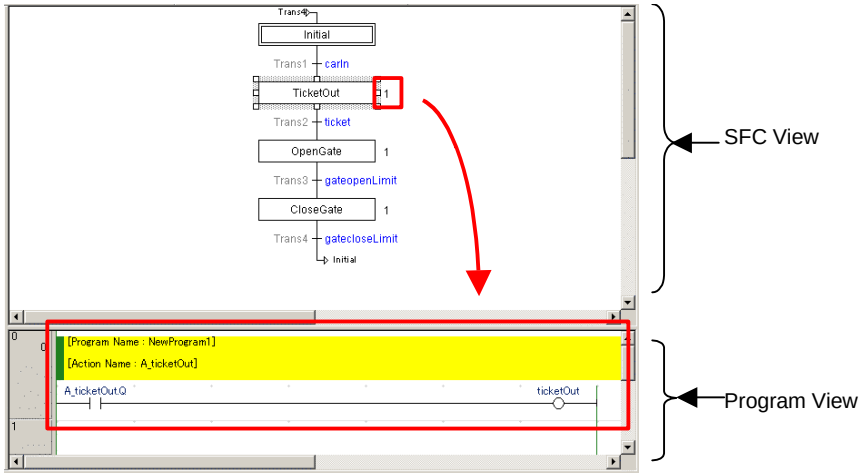
The SFC chart editor can display the SFC view and program view in a horizontally or vertically split window, allowing an SFC chart and action block (or transition program) to be viewed and edited at the same time.

In addition, action blocks can be hidden in the SFC view, but action programs and transition programs can be viewed and edited in the program view, even when the action blocks are hidden in the SFC chart. Processing contents and transition conditions can be viewed and edited while envisioning the entire program picture, allowing the features of SFC to be fully realized.

Action Blocks Shown



Action Blocks Hidden



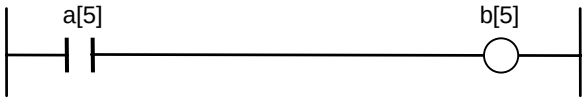
Online Editing and Debugging

SFC charts can be edited online. Furthermore, action blocks can be hidden while debugging, and the step progression status can be checked. The SFC chart editor will display the action programs in the program view, even while the action blocks are hidden.

Array Variables

Array variables can be used in ST and SFC, in addition to being able to use them in conventional ladder programs, executed for tasks in CX-Programmer.

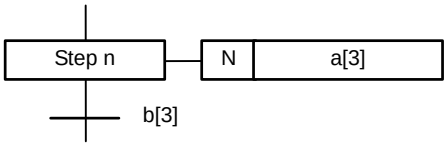
Ladder



ST

```
b[7] := a[7]
```

SFC



1-2 CX-Programmer Specifications

This section describes the CX-Programmer's operating environment in which SFC functions can be used. For details on the basic CX-Programmer operating environment, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

1-2-1 PLC Models Supporting SFC

The following PLCs (Programmable Logic Controllers) support the SFC language.

PLC model	CPU model
CJ2H unit version 1.0 or later	CJ2H-CPU68/67/66/65/64/68-EIP/67-EIP/66-EIP/65-EIP/64-EIP
CJ2M unit version 1.0 or later	CJ2M-CPU11/12/13/14/15/31/32/33/34/35
CS1G-H unit version 4.0	CS1G-CPU45H/44H/43H/42H
CS1H-H unit version 4.0	CS1H-CPU67H/66H/65H/64H/63H
CJ1G-H unit version 4.0	CJ1G-CPU45H/44H/43H/42H
CJ1H-H unit version 4.0	CJ1H-CPU67H/66H/65H/67H-R/66H-R/65H-R/64H-R
CJ1M unit version 4.0	CJ1M-CPU23/22/21/13/12/11

Note

- SFC cannot be used on CP-series PLCs.
- Microsoft .Net Framework 1.1 or later must be installed.
- Internet Explorer 5.□ or later must be installed.

1-2-2 Specifications

Item	Details
Programming language for tasks	SFC, ladder, or ST (In any combination)
SFC program unit	Tasks (1 task = 1 SFC chart) CJ2: 384 tasks max. (128 cyclic tasks, 256 extra tasks) Other models: 288 tasks max. (32 cyclic tasks, 256 extra tasks)
Tasks supported for SFC program allocation	Cyclic or extra tasks
SFC elements	Steps, transitions, actions, jumps, subcharts Note: SFC elements are automatically registered to local variables.
SFC chart shapes	Series, divergence/convergence, simultaneous sequence divergence/convergence, jump **Note:** Number of divergences/convergences, simultaneous sequence divergences/convergences, and subcharts are unlimited. (Unlike with SFC for CV series)
Step status	Active, inactive **Note:** PAUSE and HALT are not supported. (Unlike with SFC for CVM1/CV series)
Transitions *	Boolean address bits (Boolean variables or actual addresses), ST expressions, or transition programs **Note 1:** A ladder or ST program can be used for a transition program. **2:** Function blocks can be used for transition programs.
Transition program transition conditions	A transition condition is met when the Boolean variable with the same name as the transition program is switched to "ON".
Action blocks	Action Qualifiers (AQ) (11 types) + action **Note 1:** There is no restriction on the number of action blocks allocated to a step. **2:** If there are multiple action programs in the same step, the execution order is determined by the order (top to bottom) that the action programs are listed in the project workspace. **3:** An action program is executed just once per cycle (unlike the CV-series SFC operation), even if the action program is used in multiple steps and the multiple steps are active at the same time.

Action qualifiers (11 types)		N, P, P1, P0, L, D, R, S, SL, SD, DS
Actions *		Boolean address bits (Boolean variables or actual addresses) or action programs **Note 1:** A ladder or ST program can be used for an action program. **2:** Function blocks can be used for action programs.
Output reset		When a step has become inactive, the action block's outputs can be reset by any one of the following methods. Select the output reset in the action's properties (unless the action is Boolean or an ST program). The reset operation depends upon the type of program added, as follows. • Specified bit: Reset. • Ladder program: The default setting is to reset outputs. If you do not want the outputs reset, specify that in the action program's properties. • ST program: Not reset.
Direct addressing		An actual address can be specified for an action or transition using an SFC chart's Boolean action/transition or a ladder program. Only variables can be used to specify addresses in ST programs. (Direct addressing is not possible.)
Step control		Step activation/ deactivation
SFC task control	Step timer readings/ updates	Steps in an SFC chart can be activated or deactivated from the following ladder programs (by using the "SA" step activation instruction and the "SE" step deactivation instruction). * Ladder program outside of SFC programs * Action ladder program within an SFC program * Action ladder program within another SFC program
	Executing and ending SFC tasks	Time elapsed since the activation of a step can be read and updated (by using the "TSR" read step timer value instruction and the "TSW" set step timer value instruction). 0 to 6553.5 sec (Unit: 100 millisecond), or 0 to 65535 sec (Unit: 1 sec)
Force Step	Stopping SFC tasks (output reset or output hold)	The execution and ending of SFC tasks can be controlled from the ladder program with the SFC Task Control Instructions. Execute: If the SFC task was completed, the SFC task status is completely reset and execution proceeds from the initial step. If the SFC task was stopped, the SFC task is executed from the step where the task was stopped. End: The status of outputs is held, and the SFC task is ended.
	Transitions can be force-set/force-reset online, for a step-by-step execution.	SFC tasks can be stopped (outputs reset or outputs held) from the ladder program with the SFC Task Control Instructions. Output reset: Resets the outputs, and pauses the SFC task. Output hold: Retains the output status, and pauses the SFC task.
Online Editing		Allows SFC chart editing, actions addition/deletion, and transitions addition/deletion. **Note**: Choose between standard mode (transfer with source code) and quick mode (transfer without SFC source code).
Variables	Array variables	Array variables are supported for SFC, ladder, and ST programs.
	Structure variables	Structure variables are supported for ladder/ST action programs and ladder/ST transition programs. (They cannot be used on the SFC chart view or Sub-chart view.)
	TIMER / COUNTER type variables	TIMER/COUNTER type variables are supported for ladder/ST action programs and ladder/ST transition programs. (They cannot be used on the SFC chart view or Sub-chart view.)

* The maximum number of transition programs, action programs, and subcharts is as follows (when using function blocks, number of definitions are included):

CJ2H CPU Units: 2,048 max.

CJ2M CPU Units:

CJ2M-CPU□1/□2/□3: 256 max.

CJ2M-CPU□4/□5: 2,048 max.

CS1H /CJ1H CPU Units: 1024 max.

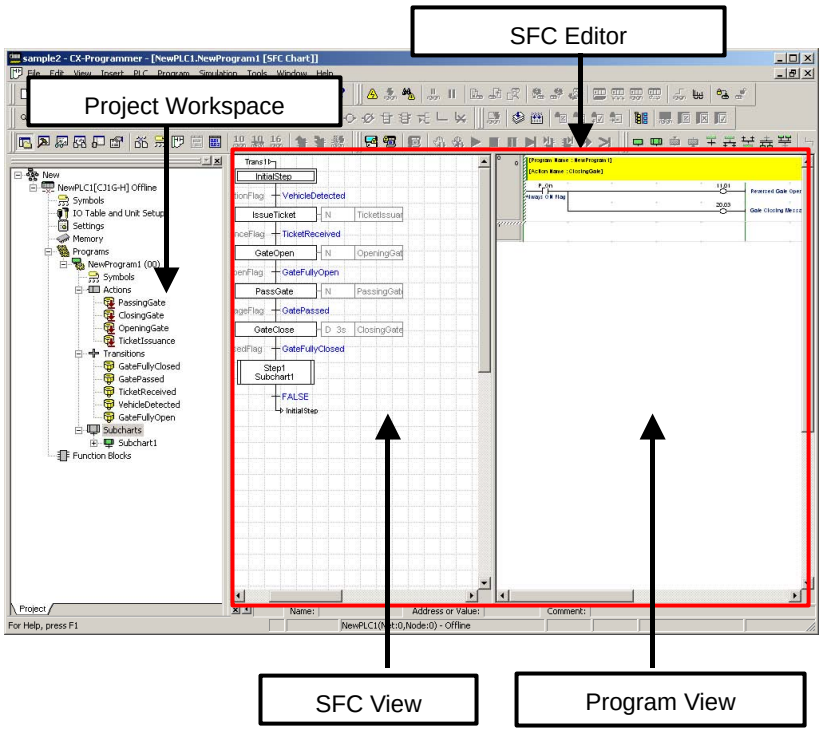
CJ1M CPU Units: 256 max.

1-3 Window Components

This section describes the CX-Programmer's SFC chart editing functions and functions related to the SFC editor. For details on other functions, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

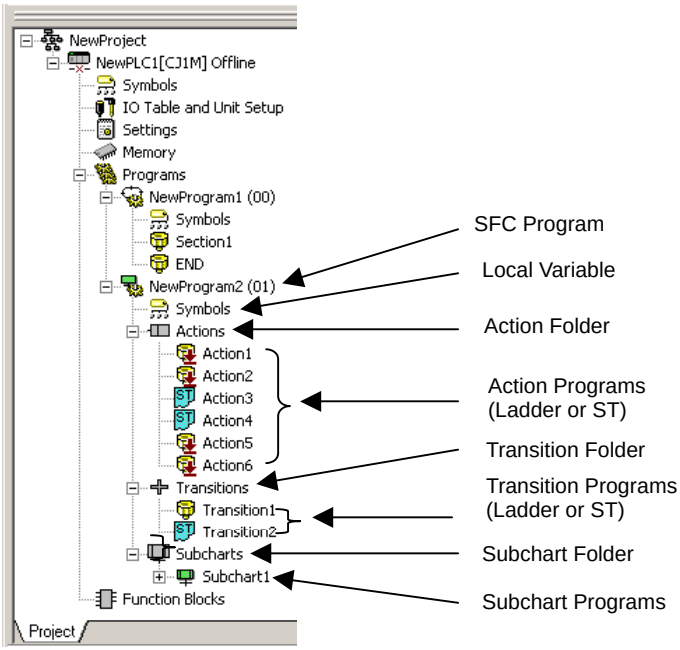
1-3-1 SFC Editor

SFC elements can be inserted and connected in the CX-Programmer's SFC editor to create sequential step programs. The project workspace and SFC editor can be displayed in a horizontally or vertically split window, so that the structural relationship between the SFC chart and action block (or transition program) can be clearly understood.



Project Workspace

SFC programming elements are hierarchically displayed and managed.
The Project Workspace is also known as the Project Tree.



SFC Programs

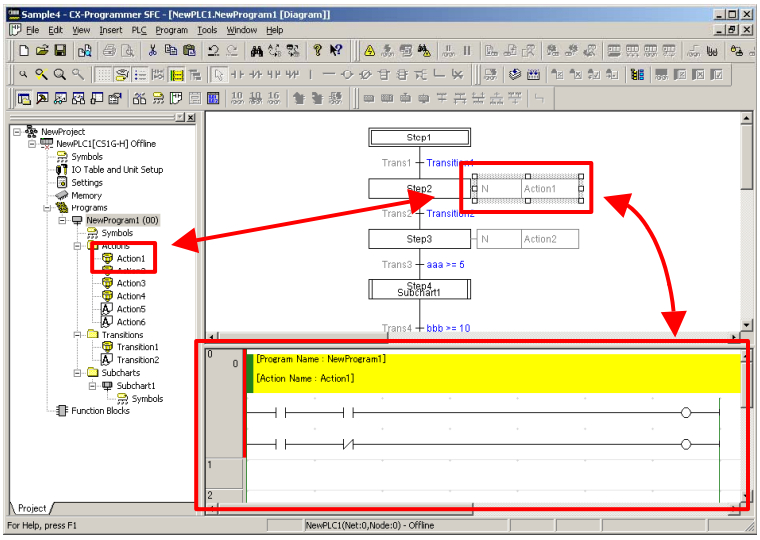
SFC programs are registered as child items of the *Programs* folder in the project workspace. Task allocation is required to execute the SFC program.

Symbol Tables

Variables are automatically registered in the symbol table, corresponding to the SFC elements created in the SFC chart. The variables registered here are used as local variables in the SFC chart. Also, the user can register the variables that are required while writing the SFC program.

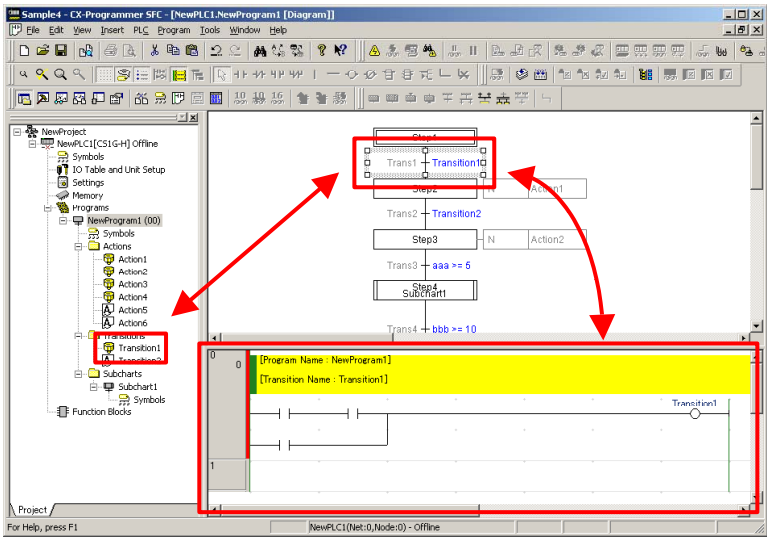
Actions Folder and Action Programs

Action programs are registered in the *Actions* folder under the SFC program structure. An action program describes the step actions in ladder or ST.
Action programs are associated to an action block within an SFC chart by selecting the relevant action name.



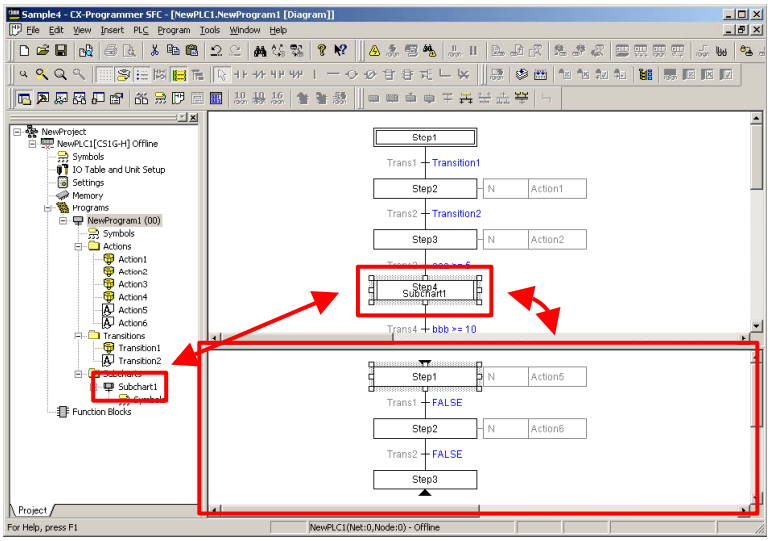
Transitions Folder and Transition Programs

Transition programs are registered in the *Transitions* folder under the SFC program. A transition program describes the step progression conditions, which need to be expressed by multiple input signals or by the more complex ladder or ST logic. Transition programs are associated with an SFC chart's transition by selecting the same transition name.



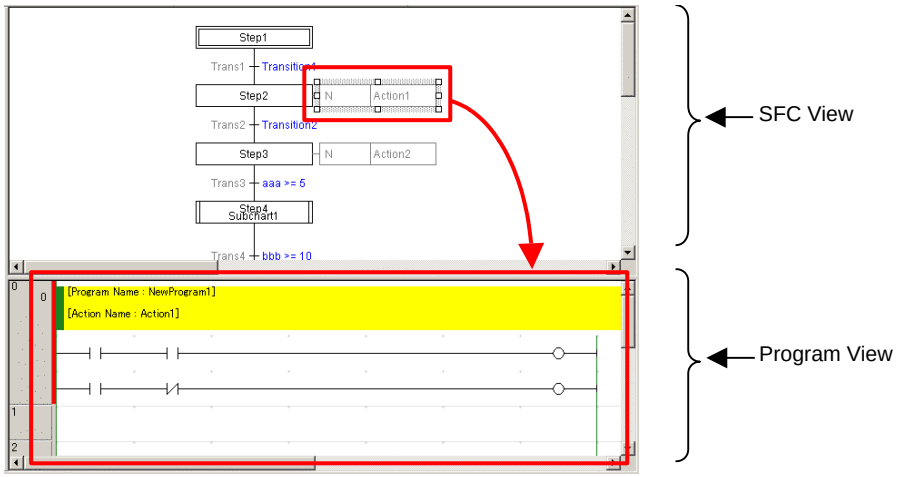
Subcharts Folder and Subchart Programs

Subchart programs are registered in the *Subcharts* folder under the SFC program. A subchart program allows an SFC program with large-scale step progression control to be developed in parts, improving the reusability and visibility of the program and allowing for more structured programming of the SFC program.
Subchart programs are subcharts for SFC charts and are associated with an SFC chart by selecting the same subchart name. In program view, it is possible to check whether an SFC subchart is a partial SFC chart of the SFC program.



SFC Editor

Displays an SFC chart or subchart.
By providing a split SFC view and program view display, the SFC chart can be viewed simultaneously with the associated action program or transition program.



SFC Editor Display Customization

Select ***Tools*** - ***Options*** from the menu, and then the **Appearance** or **SFC** tab to customize the SFC editor display.
For details on customizing the SFC editor display, refer to *1-3-6 Environmental Settings Unique to the SFC Programming Functions.*

SFC View

Displays an SFC chart or subchart.

Program View

Displays the action program, transition program, or subchart for the action block, transition, or subchart step, selected in the SFC view.
The action program, transition program, or subchart program can be edited in program view, while viewing the SFC chart in the SFC editor.

1-3-2 Menus

Edit Menu

This menu is displayed when the SFC editor is displayed in the main editing window and has the cursor focus. Menu items are enabled and disabled depending on which SFC element is selected in the SFC editor.

Menu	Sub-Menu	Function
Edit Step Name		Enables editing of the selected step name.
Edit Transition Condition		Enables editing of a selected transition name.
Edit Action Name		Displays a combo box in the selected action block, enabling selection of the action program name.
Edit Action Qualifier		Displays a combo box in the action qualifier of the selected action block, enabling action qualifier selection.
Edit Action Qualifier Time		Enables editing of the selected action block's action qualifier timer.
Edit Action Indicator Variable		Enables editing of the selected action block's indicator variable.

Edit Connections	Add Connection To SFC Element	Draws out a connection from the topside of the selected SFC element.
	Add Connection From SFC Element	Draws out a connection from the downside of the selected SFC element.
	Delete Connection To SFC Element	Deletes the connection on the topside of the selected SFC element.
	Delete Connection From SFC Element	Deletes the connection on the downside of the selected SFC element.
Tidy Element Positions		Arranges all of the elements in the SFC chart.
Tidy Descendant Element Positions		Arranges the SFC chart elements positioned after the selected SFC element.

View Menu

This menu is enabled only when the display magnifier for the SFC editor has been changed.

Menu	Function
Zoom Reset	Resets the scaling ratio of the SFC editor to 100%.

Insert Menu

This menu is enabled only when the SFC editor is displayed.

Menu	Function
Step	When a bottom transition is selected, this item adds a step and connects it to the transition. When a transition is not selected, it inserts an independent step.
Subchart Step	When a bottom transition is selected, this item adds a subchart step and connects it to the transition. When a transition is not selected, it inserts an independent subchart step.
Transition	When a bottom step is selected, this item adds a transition and connects it to the step. When a step is not selected, it inserts an independent transition.
Divergences	When a bottom step is selected, this item adds a divergence and 2 transitions, and connects them to the step. When a step is not selected, it adds a step, a divergence, and 2 transitions.
Convergences	When a conditionally-branched bottom transition is selected, this item adds a convergence and a step, and connects them to the transition.
Simultaneous Sequence Divergences	When a bottom transition is selected, this item adds a simultaneous sequence divergence and 2 steps, and connects them to the transition. When a transition is not selected, it adds a transition, a simultaneous sequence divergence, and 2 steps.
Simultaneous Sequence Convergences	When a parallel-branched bottom step is selected, this item adds a simultaneous sequence convergence and a transition, and connects them to the step.

Step and Transition	When a bottom transition is selected, this item adds a step and a transition, and connects them to the transition.
Transition and Step	When a bottom step is selected, this item adds a transition and a step, and connects them to the step.
Simultaneous Convergent Step Above	Inserts a step on the topside of a simultaneous sequence convergence.
Convergent Transition Above	Inserts a transition on the topside of a convergence.
Connector	Draws a connection from an SFC element that does not have a connection in the SFC chart.

Program Menu

This menu is enabled only when the SFC editor is displayed.

Menu		Function
Online Edit	Transfer SFC/ST Source to PLC (Online Edit)	When an SFC program revision is being transferred in quick mode during online SFC chart editing, only the SFC source code is transferred later.
	Release FB/SFC/ST, Online Edit Access Rights	Makes PLC access rights invalid in the event of process interruption, due to communication error during online SFC chart editing.

1-3-3 SFC Editor Pop-up Menu

This section describes menus, which are displayed by right-clicking within the SFC editor.
The menu displayed depends on which SFC element is selected. Furthermore, menu items are enabled and disabled depending on the connected state of SFC elements.

Right-Clicking a Step

The step elements menu for working online differs from that for working offline.

Offline Pop-Up Menu

Menu	Sub-Menu	Function
Edit Step Name		Enables editing of the selected step name.
Step Type	Normal	Changes the selected step to a normal step.
	Initial	Changes the selected step to an initial step.
	Entry	Changes the selected step to a entry step.
	Return	Changes the selected step to a return step.
Step Timer	Use Millisecond Timer	Sets the step timer unit to 100 milliseconds.
	Use Second Timer	Sets the step timer unit to 1 second.
Add Action	Boolean Action	Adds a Boolean variable or actual address to the selected step.
	New Ladder Action	Creates a new ladder program, and adds it to the selected step.
	New Structured Text Action	Creates a new ST program, and adds it to the selected step.
	Existing Action	Adds an already registered action to the selected step.
Show Action Blocks		Shows hidden action blocks.
Add Transition and Step		Adds a transition and a step, and connects them to the selected step.
Add Transition		Adds a transition and connects it to the selected step.
Insert Step and Transition Above		Adds a transition and a step, and connects them to the topside of the selected step.
Insert Transition Above		Adds a transition to the topside of the selected step.
Add Divergences		Adds a divergence and 2 transitions, and connects them to the selected step.
Add Simultaneous Sequence Convergence		Adds a simultaneous sequence convergence and a transition, and connects them to the selected step.

Connections	Add Connection	Opens the Add Connection dialog.
	Add Jump to Step	Draws out a connection from the topside of the selected step, and connects it to the downside of the transition that is to become the jump starting point.
	Add Connection To Step	Draws out a connection from the topside of the selected step, and connects it to the downside of a transition.
	Delete Connection To Step	Deletes the connection on the topside of the selected step.
	Draw Connections to Step as Jump	Changes the topside of the selected step to a jump.
	Add Connection From Step	Draws out a connection from the downside of the selected step, and connects it to the topside of a transition.
	Delete Connection From Step	Deletes the connection on the downside of the selected step.
Open Subchart Definition		Opens a subchart.
Cut		Cuts the selected step to the clipboard.
Copy		Copies the selected step to the clipboard.
Paste		Pastes the contents of the clipboard.
Delete		Deletes the selected step.
Tidy Descendant SFC Elements		Arranges elements of the SFC chart positioned after the selected step.

Online Pop-Up Menu

Menu	Sub-Menu	Function
Force Step	On	Activates the selected step.
	Off	Deactivates the selected step.
	Cancel	Cancels the forced status.
Set Step Timer Value		Updates the step timer value.
Open Subchart Definition		Opens a subchart.
Show Action Blocks		Shows hidden action blocks.
Tidy Descendant SFC Elements		Arranges elements of the SFC chart positioned after the selected step.

Right-Clicking a Transition

The transition elements menu for working online differs from that for working offline.

Offline Pop-Up Menu

Menu	Sub-Menu	Function
Edit Transition Condition		Enables editing of the selected transition condition.
Add Step and Transition		Adds a step and a transition, and connects them to the selected transition.
Add Step		Adds a step and connects it to the selected transition.
Insert Transition and Step Above		Adds a transition and a step, and connects them to the topside of the selected transition.

Insert Step Above		Adds a step to the topside of the selected transition
Add Convergence		Adds a convergence and a step, and connects them to the selected transition.
Add Simultaneous Sequence Divergence		Adds a simultaneous sequence divergence and 2 steps, and connects them to the selected transition.
Connections	Add Connection	Opens the Add Connection dialog.
	Add Jump From Transition	Draws out a connection from the downside of the selected transition, and connects it to the topside of the step that is to become the jump destination.
	Add Connection From Transition	Draws out a connection from the downside of the selected transition, and connects it to the topside of a step.
	Delete Connection From Transition	Deletes the connection on the topside of the selected transition.
	Draw Connections From Transition as Jump	Changes the topside of the selected transition to a jump.
	Add Connection To Transition	Draws out a connection from the topside of the selected isolated transition, and connects it to the downside of a step.
	Delete Connection To Transition	Deletes the connection on the downside of the selected transition.
Add Subchart Step	New Subchart	Creates and adds a new subchart, and connects it to the selected transition as a subchart step.
	Existing Subchart	Connects an already registered subchart to the selected transition as a subchart step.
Open Transition Definition		Opens the selected transition program.
Cut		Cuts the selected transition to the clipboard.
Copy		Copies the selected transition to the clipboard.
Paste		Pastes the contents of the clipboard.
Delete		Deletes the selected transition.
Tidy Descendant SFC Elements		Arranges SFC chart elements positioned after the selected transition.

Online Pop-Up Menu

Menu	Sub-Menu	Function
Force Step	On	Sets the transition condition to ON.
	Off	Sets the transition condition to OFF.
	Cancel	Cancels the forced status.
Open Transition Definition		Displays the selected transition program.
Tidy Descendant SFC Elements		Arranges SFC chart elements positioned after the selected transition.

Right-Clicking a Divergence

Menu	Sub-Menu	Function
Add Divergent Transition Branch		Adds a transition to the right side of the selected divergence.
Insert Step Above		Adds a step and connects it to the topside of the selected divergence.
Insert Transition and Step Above		Adds a transition and a step, and connects them to the topside of the selected divergence.
Connections	Add Connection	Opens the Add Connection dialog.
	Add Connection To Divergence	Draws out a connection from the topside of the selected divergence, and connects it to the downside of a step.
	Add Connection From Divergence	Draws out a connection from the downside of the selected divergence, and connects it to the topside of a transition.
	Delete Connection To Divergence	Deletes the connection on the topside of the selected divergence.
	Delete Connection From Divergence	Deletes the connection on the downside of the selected divergence.
Use Default Transition Precedence		The order of execution can be set by deselecting (removing the check marks) items. (By default, the execution order is from left to right, and numbers are not displayed.)
Cut		Cuts the selected divergence to the clipboard.
Copy		Copies the selected divergence to the clipboard.
Paste		Pastes the contents of the clipboard.
Delete		Deletes the selected divergence.
Tidy Descendant SFC Elements		Arranges elements of the SFC chart positioned after the selected divergence.

Right-Clicking a Convergence

Menu	Sub-Menu	Function
Add Convergent Transition Branch		Adds a transition to the right side of the selected convergence.
Add Step		Adds a step and connects it to the selected convergence.
Add Subchart Step	New Subchart	Creates and adds a new subchart, and connects it to the selected convergence as a subchart step.
	Existing Subchart	Connects an already registered subchart to the selected convergence as a subchart step.
Add Step and Transition		Adds a step and a transition, and connects them to the selected convergence.

Connections	Add Connection	Opens the Add Connection dialog.
	Add Connection To Convergence	Draws out a connection from the topside of the selected convergence, and connects it to the downside of a transition.
	Add Connection From Convergence	Draws out a connection from the downside of the selected convergence, and connects it to the topside of a step.
	Delete Connection To Convergence	Deletes all connections on the topside of the selected convergence.
	Delete Connection From Convergence	Deletes the connection on the downside of the selected convergence.
Cut		Cuts the selected simultaneous sequence divergence to the clipboard.
Copy		Copies the selected simultaneous sequence divergence to the clipboard.
Paste		Pastes the contents of the clipboard.
Delete		Deletes the selected convergence.
Tidy Descendant SFC Elements		Arranges SFC chart elements positioned after the selected Convergence.

Right-Clicking a Simultaneous Sequence Divergence

Menu	Sub-Menu	Function
Add Simultaneous Divergent Step Branch		Adds a step to the right side of the selected simultaneous sequence divergence.
Insert Transition Above		Adds a transition to the topside of the selected simultaneous sequence divergence.
Insert Step and Transition Above		Adds a step and a transition, and connects them to the topside of the selected simultaneous sequence divergence.
Connections	Add Connection	Opens the Add Connection dialog.
	Add Connection To Divergence	Draws out a connection from the topside of the selected simultaneous sequence divergence, and connects it to the downside of a transition.
	Add Connection From Divergence	Draws out a connection from the downside of the selected simultaneous sequence divergence, and connects it to the downside of a step.
	Delete Connection To Divergence	Deletes the connection on the topside of the selected simultaneous sequence divergence.
	Delete Connection From Divergence	Deletes the connection on the downside of the selected simultaneous sequence divergence.
Cut		Cuts the selected simultaneous sequence divergence to the clipboard.
Copy		Copies the selected simultaneous sequence divergence to the clipboard.
Paste		Pastes the contents of the clipboard.
Delete		Deletes the selected simultaneous sequence divergence.
Tidy Descendant SFC Elements		Arranges SFC chart elements positioned after the selected simultaneous sequence divergence.

Right-Clicking a Simultaneous Sequence Convergence

Menu	Sub-Menu	Function
Add Simultaneous Sequence Convergent Step Branch		Adds a step and connects it to the topside of the selected simultaneous sequence convergence.
Add Transition		Adds a transition and connects it to the selected simultaneous sequence convergence.
Add Transition and Step		Adds a transition and a step, and connects them to the selected simultaneous sequence convergence.
Connections	Add Connection	Opens the Add Connection dialog.
	Add Connection To Convergence	Draws out a connection from the topside of the selected simultaneous sequence convergence, and connects it to the downside of a step.
	Add Connection From Convergence	Draws out a connection from the downside of the selected simultaneous sequence convergence, and connects it to the topside of a transition.
	Delete Connection To Convergence	Deletes all connections on the topside of the selected simultaneous sequence convergence.
	Delete Connection From Convergence	Deletes the connection on the downside of the selected simultaneous sequence convergence.
Cut		Cuts the selected simultaneous sequence convergence to the clipboard.
Copy		Copies the selected simultaneous sequence convergence to the clipboard.
Paste		Pastes the contents of the clipboard.
Delete		Deletes the selected simultaneous sequence convergence.
Tidy Descendant SFC Elements		Arranges SFC chart elements positioned after the selected simultaneous sequence convergence.

Right-Clicking an Action Block

Menu	Sub-Menu	Function
Edit Action Name		Displays a combo box in the selected action block, enabling selection of the action program name.
Edit Action Qualifier		Displays a combo box in the action qualifier of the selected action block, enabling action qualifier selection.
Edit Action Qualifier Time		Enables editing of the selected action block's action qualifier timer.
Open Action Program Definition		Opens the selected action program.
Add Action	Boolean Action	Adds a Boolean variable or actual address to the selected action block.
	New Ladder Action	Creates a new ladder program, and adds it to the selected action block.
	New Structured Text Action	Creates a new ST program, and adds it to the selected action block.

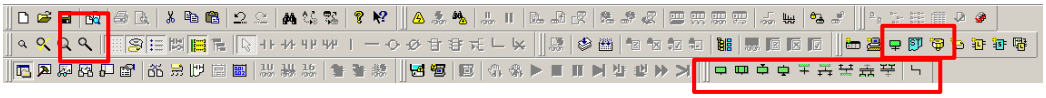
	Existing Action	Adds an already registered action to the selected action block.
Display Indicator Variable on Chart		Indicator valuables may be shown/hidden.
Edit Action Indicator Variable		Enables editing of the selected action block's indicator variable.
Cut		Cuts the selected action block to the clipboard.
Copy		Copies the selected action block to the clipboard.
Paste		Pastes the contents of the clipboard.
Delete		Deletes the selected action block.

Right-Clicking the SFC Editor Background

Menu	Sub-Menu	Function
Add Step		Inserts an independent step.
Add Subchart Step	New Subchart	Creates a new subchart and inserts it as an independent subchart step.
	Existing Subchart	Inserts an already registered subchart as an independent subchart step.
Add Transition		Inserts an independent transition.
Add Divergence		Inserts an independent divergence.
Add Convergence		Inserts an independent convergence.
Add Simultaneous Sequence Divergence		Inserts an independent simultaneous sequence divergence.
Add Simultaneous Sequence Convergence		Inserts an independent simultaneous sequence convergence.
Add Step and Transition		Adding a Step and a Transition.
Add Transition and Step		Adding a transition and a step.
Add Connector		Inserts a connection for the selected SFC element.
Show All Action Blocks		Displays all action blocks.
Hide All Action Blocks		Hides all action blocks.
Cut		-
Copy		-
Paste		Pastes the contents of the clipboard.
Delete		-
Select All		Selects all SFC elements in the SFC chart.
Tidy All SFC Elements		Arranges all elements in the SFC chart.
Import/Export	Import from XML File	Loads a program saved in XML format.
	Import from Structured Text File	Loads a program saved in ST format.
	Export as XML File	Creates program file in XML format.
	Export as Structured Text File	Creates program file in ST format.

1-3-4 Toolbar Icons

This section lists toolbar items were not supported in CX-Programmer version 7.2, but were added for SFC Programming Functions.



Ladder Diagram Toolbar

Icon	Pop-up Menu	Function
	Zoom Reset	Resets the scaling ratio of the SFC editor to 100%.

Insert Toolbar

Icon	Pop-up Menu	Function
	Insert SFC Program	Creates a new SFC program.
	Insert ST Program	Creates a new ST program.

SFC Toolbar

Icon	Pop-up Menu	Function
	Add Step	Adds an SFC step.
	Add Subchart Step	Adds an SFC subchart step.
	Add Entry Step	Adds an SFC subchart entry step.
	Add Return Step	Adds an SFC subchart return step.
	Add Transition	Adds an SFC transition.
	Add Divergences	Adds an SFC divergence.
	Add Convergence	Adds an SFC convergence.
	Add Simultaneous Divergence	Adds an SFC simultaneous sequence divergence.
	Add Simultaneous Convergence	Adds an SFC simultaneous sequence convergence.
	Add Connector	Adds an SFC connection.

1-3-5 Keyboard Shortcuts

Shortcuts

The following shortcuts can be used in SFC chart editor.

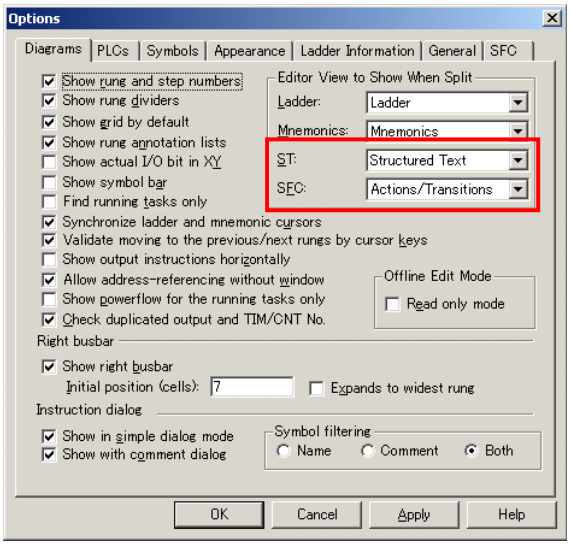
Menu	Shortcut	Function
SFC Editing: Step	S	When a bottom transition is selected, this shortcut adds a step and connects it to the transition. When no SFC element is selected within the SFC chart, inserts an independent step.
SFC Editing: Transition	T	When a bottom step is selected, this shortcut adds a transition and connects it to the step. When no SFC element is selected within the SFC chart, inserts an independent transition.
SFC Editing: Step and Transition	Shift+S	When a bottom transition is selected, this shortcut adds a step and a transition, and connects them to the transition.
SFC Editing: Transition and Step	Shift+T	When a bottom step is selected, this shortcut adds a transition and a step, and connects them to the step.
SFC Editing: Subchart	U	When a bottom transition is selected, this shortcut adds a subchart step and connects it to the transition. When no SFC element is selected within the SFC chart, inserts an independent subchart step.
SFC Editing: Connections	L	When an SFC element is selected, this shortcut displays the Add Connection dialog.
SFC Editing: Join	C	Adds a join to a bottom SFC element. When a transition is selected, this shortcut adds a convergence. When a step is selected, it adds a simultaneous sequence convergence.
SFC Editing: Branch	D	Adds a branch to a bottom SFC element. When a transition is selected, this shortcut adds a simultaneous sequence divergence. When a step is selected, it adds a divergence.
SFC Editing: Unconnected Step	Shift+P	Inserts an independent step.
SFC Editing: Unconnected Transition	Shift+R	Inserts an independent transition.
SFC Editing: Editing of Selected Parts	E	Enables editing for the selected SFC element (i.e. of the name). When an action block is selected, this shortcut displays the action program selection combo box.
SFC Editing: Action Qualifier (AQ)	Q	When an action block is selected, this shortcut displays the action qualifier selection combo box.
SFC Editing: Actions	A	When a step is selected, this shortcut adds an action block to the step.
SFC Editing: Initial Step	I	When a step is selected, this shortcut changes the step to an initial step.
SFC Editing: Align	J	Arranges SFC chart elements positioned after the selected SFC element.
SFC Editing: Tidy All SFC Elements	Shift+J	Arranges all elements in the SFC chart.

1-3-6 Environmental Settings Unique to the SFC Programming Functions

This section lists environmental setting functions were not supported in CX-Programmer, but were added for SFC Programming Functions. Environmental settings include the operating settings of the SFC programming functions, operation settings, and display settings.

1 Select ***Tools*** - ***Options*** from the menu.
The Options dialog will be displayed.
2 Select a tab and configure the settings.
3 Click ***Apply*** - ***OK***.

Diagrams Tab Page



Editor View to Show When Split: ST (Default: Structured Text)

Sets the content to be displayed when the ST program edit window is in a split window.
Select from ***Structured Text*** and ***Symbols***.
The setting is enabled when the project is saved and reopened.

Structured Text

Allows different sections of the same ST program to be viewed in a split window.

Symbols

Displays the ST program edit window and the local symbol table at the same time.

Editor View to Show When Split: SFC (Default: Actions/Transitions)

Sets the content to be displayed in a split window in an SFC editor.
Select from ***Actions/Transitions***, ***SFC***, and ***Symbols***.
The setting is enabled when the project is saved and reopened.

Actions/Transitions

Displays an SFC chart in the SFC editor's SFC view, and an action program or a transition program (ladder or ST) in the SFC editor's program view.

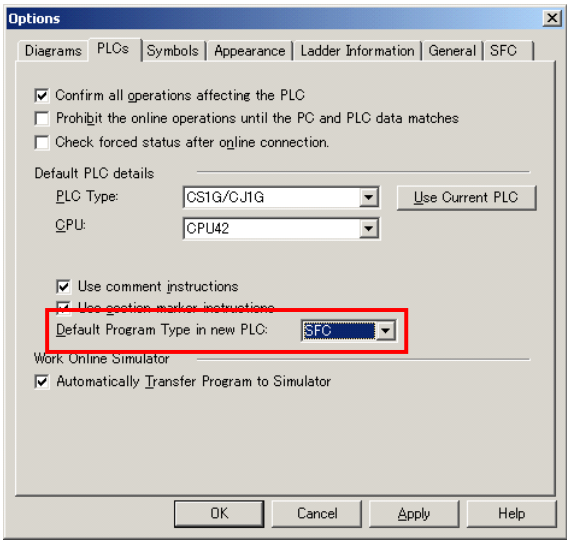
SFC

Displays a single SFC chart in the SFC editor's SFC view and program view.
The different parts of the single SFC chart can be seen.

Symbols

Displays the local symbol table and SFC chart in the SFC editor.

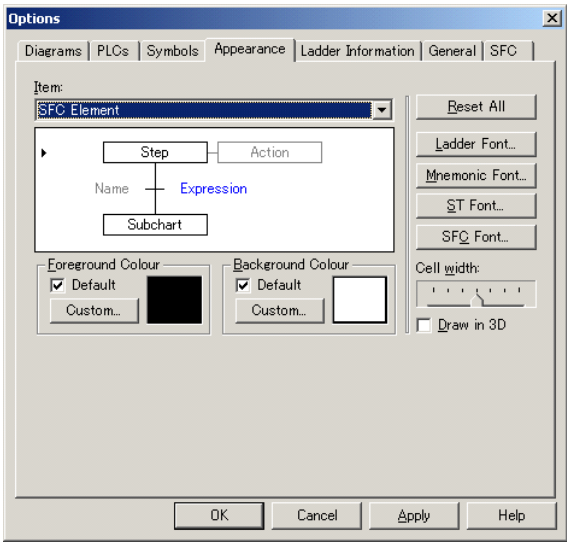
PLCs Tab Page



Default Program Type in New PLC (Default: SFC)
Sets the default program type for new projects.
Select from ***Ladder***, ***ST***, and ***SFC***.

Appearance Tab Page

Sets the background color for the SFC editor, the display color for the SFC elements, and the font settings for text.



Setting the Display Color

1 Using the *Item* combo box, select the item to be set.
2 Click ***Custom*** and display the Color dialog.
3 Select a color and click ***OK***.
Check the ***Default*** checkbox to use the default color.
4 Click ***Apply*** - ***OK***.

The following items can be set:

- SFC background
- SFC grid line

- SFC element (Color of steps, transitions, divergences, convergences, simultaneous sequence divergences, simultaneous sequence convergences, and connections)
- SFC monitoring (active step and action block color)
- SFC action (action block color)
- SFC subchart step (subchart step color)
- SFC transition expression (Text color for transition conditions)
- SFC transition name (Text color for transition names)

Setting the Display Text

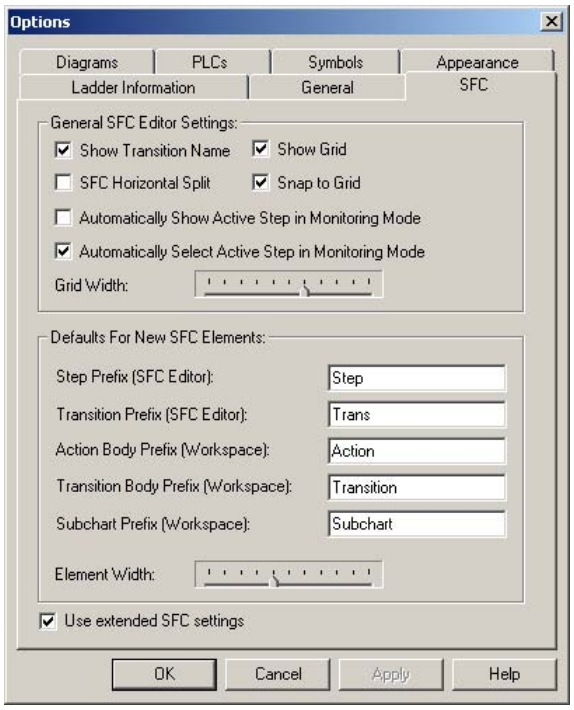
1 Click ***SFC Font*** and display the Font dialog.
2 Select the properties for the display text.
3 Click ***Apply*** - ***OK***.

The following items can be set:

- Font name
- Style
- Size
- Character set

SFC Tab Page

Sets the display settings for the SFC editor.



SFC Editor Settings

The following display settings are available for the SFC editor.

Show Grid (Default: Not Checked)

Check the checkbox to display the grid; remove the check to hide the grid.

Show Transition Names (Default: Checked)

Check the checkbox to display the transition names; remove the check to hide the transition names.

SFC Horizontal Split (Default: Checked)

Check the checkbox to split the SFC editor window horizontally; remove the check to split the window vertically. The setting is enabled when the project is saved and

reopened.

Automatically Show Active Step in Monitoring Mode (Default: Checked)
Check the checkbox to have SFC diagram editor program view automatically updated to track the active step, while debugging or editing online.

Automatically Select Active Step in Monitoring Mode (Default: Checked)
Displays the active step's action program. This function is effective when the action is hidden.

Snap to Grid (Default: Not checked)
Check the checkbox to align SFC elements to the grid when drag-and-dropped.

Grid Width
Use the slider to adjust the grid size.

Default Settings for SFC Elements

Changes to the options are for newly added elements inserted into the SFC Editor only. Existing elements keep the previous settings.
SFC elements are labeled using the specified text string and an automatically assigned number.

- Step Prefix (Display name)
- Transition Prefix (Display name)
- Action Body Prefix (Display name)
- Transition Body Prefix (Display name)
- Subchart Prefix (Display name)
- Element Width (Display width)

Note: This option setting is effective only on elements that are newly added to the SFC chart. The setting has no effect on elements that were previously added or inserted into the SFC Editor.
Note: Reserved words for addresses cannot be used as display names. (Example: S, ST, T, TN, A, AC, etc.)

Use Extended SFC Settings

When this option is selected, the following advanced settings can be used.

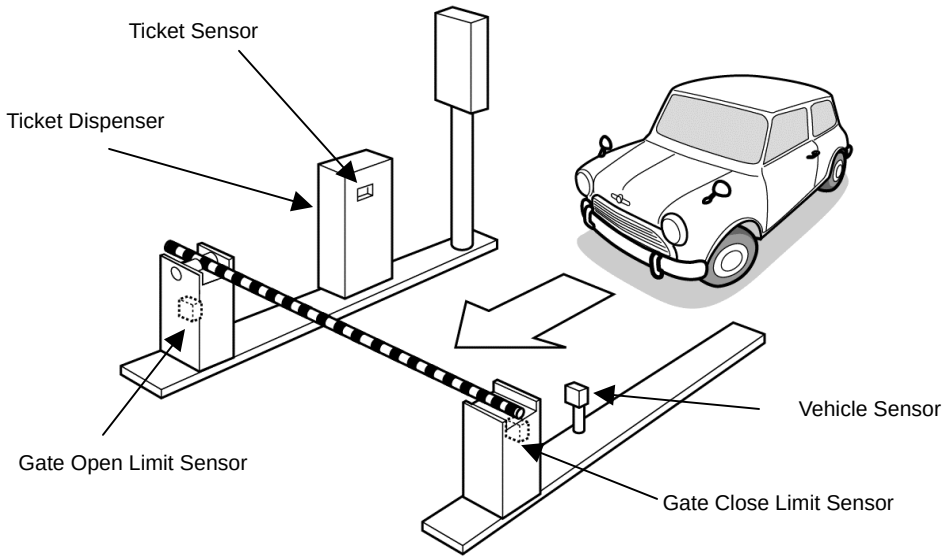
Enabling/Disabling the SFC Program's Final Scan:
The *Apply Final Scan Logic* Option can be selected in the General Tab of the SFC program's Property Dialog Box.
Option selected: Final scan execution is enabled for that entire SFC program.
Option not selected: Final scan execution is disabled for that entire SFC program.
Note: For details on the final scan function, refer to *1-5-2 Action Program Precautions*.

1-4 SFC Programming Example

The section provides a simple example of an SFC program, and describes the procedures for program development using CX-Programmer.

1-4-1 Simple Example of an SFC Program

SFC will be used to program a ticketing system for an unattended paid parking lot. Study the action flow scenario and clarify the steps and transition conditions. Check for external devices, also, and define the variables.



Action Flow Scenario for an Unattended Paid Parking Lot

A scenario is created by breaking down the action flow, as well as the statuses of the external device.

1 Waiting for an incoming car. -> Step 1: Initial step
2 When a car enters, the vehicle sensor is turned ON, and the active status is transferred to the next step.
-> Transition condition: Trans1/Vehicle sensor ON (carln)
3 When the vehicle sensor is turned ON, the ticket dispenser is turned ON, and a ticket is issued.
-> Step 2: TicketOut
-> AQ: N (Normal)
-> Action: Active ticket dispenser
4 When the ticket dispenser issues a ticket, the ticket sensor is turned OFF.
5 When the driver takes the ticket, the ticket sensor is turned OFF, and the active status is transferred to the next step. At this point, the ticket dispenser is also turned OFF.
-> Transition condition: Trans2/Ticket sensor ON (ticket)
6 When the driver takes the ticket, normal rotation of the gate motor is turned ON, and the gate begins to open.
-> Step 3: OpenGate
-> AQ: N (Normal)
-> Action: Active normal rotation of gate motor
7 When the gate is fully opened, the gate open limit sensor is turned ON, and the active status is transferred to the next step.
At this point, the normal rotation of the gate motor is turned OFF.

-> Transition condition: Trans3/Gate open limit sensor ON (gateopenLimit)

8 If 3 seconds have elapsed since the gate has fully opened, AND if the car has passed the gate and the vehicle sensor has turned OFF, the transition conditions are met. The reverse rotation of the gate motor is then turned ON, and the gate begins to close.
-> Step 4: CloseGate
-> AQ: D (Delay)
-> Action: Active reverse rotation of gate motor

9 When the gate is fully closed, the reverse rotation of the gate motor is turned OFF.
-> Step 4: CloseGate
-> Action: Activate reverse rotation of gate motor

10 When the gate is fully closed, the gate close limit sensor is turned ON, and the active status is transferred to the next step.
At this point, the reverse rotation of the gate motor is turned OFF.
-> Transition condition: Trans4/Gate close limit sensor ON (gatecloseLimit)

11 The gate returns to the waiting status, and waits for the next car.

Defining Variables for the Unattended Paid Parking Lot

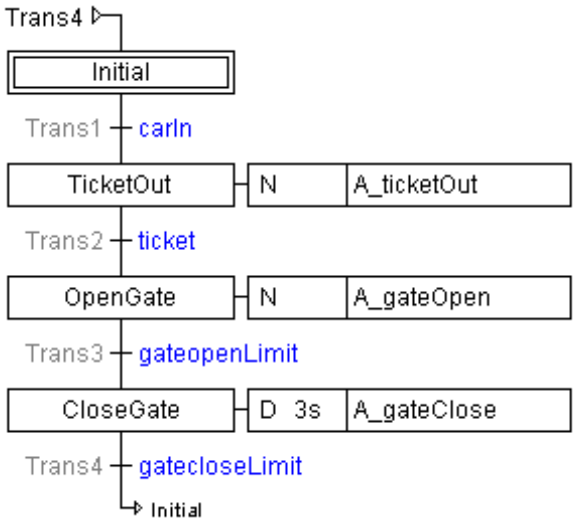
SFC program user variables must be defined for the external I/O devices.

External device	I/O	Variable name	Variable type
Vehicle sensor	Input	carIn	Boolean
Ticket sensor	Input	ticket	Boolean
Gate open limit sensor	Input	gateopenLimit	Boolean
Gate close limit sensor	Input	gatecloseLimit	Boolean
Ticket dispenser	Output	ticketOut	Boolean
Normal operation of gate motor	Output	gateopen	Boolean
Reverse operation of gate motor	Output	gateClose	Boolean

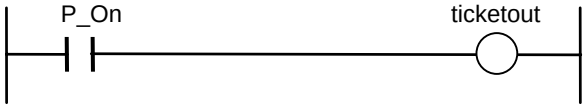
Note: It is also possible to specify actual addresses, rather than variables.

Example SFC Program for the Unattended Paid Parking Lot

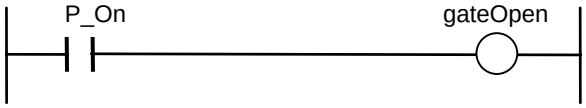
The following example shows part of an SFC program for the ticket-issuing system of an unattended paid parking lot, based on the defined action flow scenario and variables. The action program is created using ladder logic.



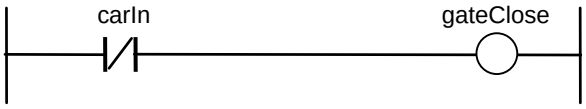
Action Program (A_tiketOut): Starting/Stopping the Ticket Dispenser



Action Program (A_gateOpen): Starting/Stopping the Normal Rotation of the Gate Motor



Action Program (A_gateClose): Starting/Stopping the Reverse Rotation of the Gate Motor



Note: Leave each action program's *Reset Output at Final Scan* setting at its default setting of ON (reset).

1-4-2 Procedures for Using CX-Programmer

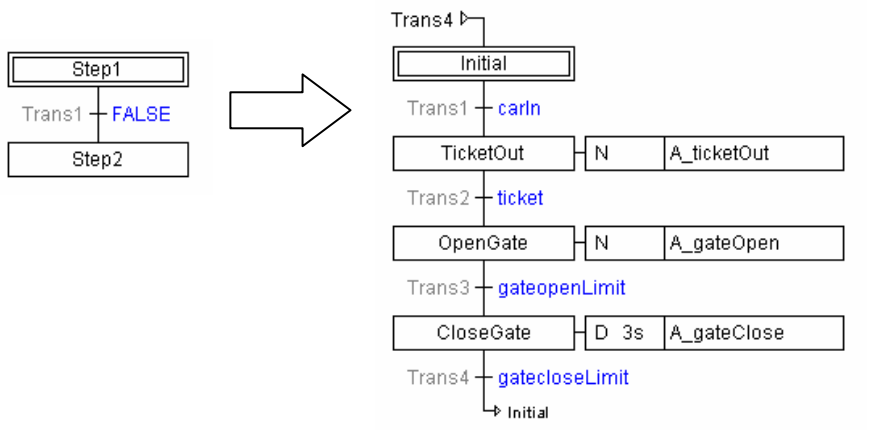
This section describes the programming flow and SFC chart editing procedure using, as an example, the SFC program for the unattended paid parking lot ticketing system.

SFC Programming Flow

1 Select and right-click a *Programs* item in the project workspace, and select ***Insert Program*** - ***SFC*** from the pop-up menu.
For details, refer to *3-1-2 Creating (Inserting) a New SFC Program*.

2 Assigning the SFC program to a task
Select and right-click an SFC program item in the project workspace, and select ***Properties*** from the pop-up menu.
On the **General** tab of the displayed Program Properties dialog, select a task from the *Task Type* list.
For details, refer to *3-1-3 Assigning an SFC Program to a Task*.

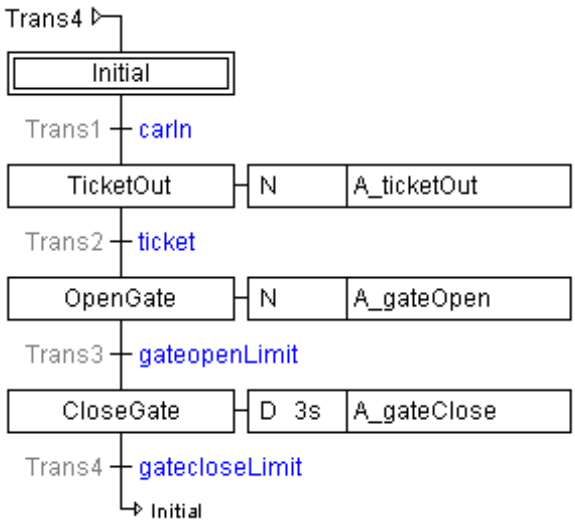
3 Editing SFC chart
When an SFC program is created, 3 types of SFC elements (initial step, transition, and step) are registered in the SFC chart editor by default. Define the transition conditions and actions by adding to these SFC elements.



4 Checking the program
Select and right-click an SFC program item in the project workspace, and select ***Compile*** from the pop-up menu.
For details, refer to *3-4-1 SFC Program Check*.

5 Transferring the SFC Program to the PLC
Select ***Transfer*** - ***To PLC*** from the PLC menu.
For details, refer to *4-2 Transferring Programs from Computer to PLC*.

Editing the SFC Chart for the Unattended Paid Parking Lot



1 Register the required user variables (**carIn**, **ticket**, **ticketOut**, **gateopenLimit**, **gatecloseLimit**, **gateOpen**, and **gateClose**) in the local symbol table.
For details, refer to *1-4-1 Simple Example of an SFC Program*.
In the project workspace, select the *Symbols* item for the SFC program item.
Right-click the symbol table, and select ***Insert Symbol***.
Enter the variable name in the *Name* field of the New Symbol dialog, and click ***OK***.

2 Create ladder action programs (**A_ticketOut**, **A_gateOpen**, **A_gateClose**) as *Actions* folder in the project workspace.
Select and right-click the *Actions* folder for the SFC program items in the project workspace, and select ***Insert Action*** - ***Ladder***.
Right-click the inserted action program, select ***Properties***, and enter the action program name.
Right-click the inserted action program, select ***Open***, and create the ladder action program.

Note: Leave the action program's *Reset Output at Final Scan* setting at its default setting of ON (reset). Make the same setting for all of the following action programs, too.

3 Input the name for Step 1.
Right-click Step 1, and select ***Edit Step Name***.
Input Initial into Step 1.

4 Input the transition condition for Step 1.
Right-click the transition after Step 1, and select *Edit Transition Condition*.
Input **carIn** as the transition condition.

5 Input the name for Step 2.
Right-click Step 2, and select ***Edit Step Name***.
Input **TicketOut** into Step 2.

6 Add an action program to the action in Step 2.
Right-click Step 2, and select ***Add Action*** - ***Existing Action***.
Double-click the right-hand side of the action block, and select ***A_ticketOut*** from the combo box.

7 Input the transition condition for Step 2.
Right-click the transition after Step 2, and select *Edit Transition Condition*.
Input **ticket** as the transition condition.

8 Input the name for Step 3.
Right-click Step 3, and select ***Edit Step Name***.
Input **OpenGate** into Step 3.

9 Add an action program to the action in Step 3.
Right-click Step 3, and select ***Add Action*** - ***Existing Action***.
Double-click the right-hand side of the action block, and select **A_gateOpen** from

the combo box.
Double-click the left-hand side of the action block, and select ***D*** from the combo box.
Double-click the timer value and input ***3***.

10 Input the transition condition for Step 3.
Right-click the transition after Step 3, and select *Edit Transition Condition*.
Input **gateopenLimit** as the transition condition.

11 Input the name for Step 4.
Right-click Step 4, and select ***Edit Step Name***.
Input **CloseGate** into Step 4.

12 Add an action program to the action in Step 4.
Right-click Step 4, and select ***Add Action*** - ***Existing Action***.
Double-click the right-hand side of the action block, and select **A_gateClose** from the combo box.

13 Input the transition condition for Step 4.
Right-click the transition after Step 4, and select *Edit Transition Condition*.
Input **gatecloseLimit** as the transition condition.

14 Add a jump to Step 1.
Right-click the transition after Step 4, and select ***Connections*** - ***Add Connection***.
On the Add Connection dialog, select ***Initial*** as the jump destination.
Check the ***Draw Connection as Jump*** checkbox and click ***OK***.

1-5 Precautions When Creating SFC Programs

1-5-1 Holding or Resetting an Action's Outputs

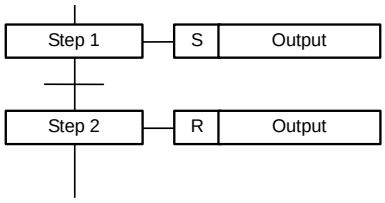
The action's type determines whether the action's outputs (see note) are held or reset when the step goes from active to inactive status.

Note: In this section, the term "output" refers to the following.

- For a bit specification, it refers to the specified bit address value in memory.
- For a ladder program, it refers to the value written in memory by an instruction.
- For an ST program, it refers to the value written in memory by a statement.

Bit Specification

- The output is reset when a holding action qualifier (S) is not specified, but a qualifier such as action qualifier (N) is specified.
- When a holding action qualifier (S) is specified, the output is held by the action qualifier's execution condition even if the step becomes inactive. In this case, the output can be reset by using a resetting action qualifier (R) and adding a step, as shown in the following chart.



Output: Boolean variable

Ladder Program

With the default setting, the outputs are reset.

If you want to retain the output status, deselect the ladder program's *Reset Output at Final Scan* Option (remove the check mark).

Note 1. When timer instructions are being used and outputs are set to be held (not reset), the Timer Completion Flags will also be held, and the next time that the same action is executed, it will start execution with the Timer Completion Flag ON. If you want to reset the timer Completion Flags separately, include the action flag (see note 2) in the timer instruction's input condition by ANDing the flag as a NO condition to reset the timer.

2. The action flag is ON when the step is active, and OFF when the step is inactive. The flag is written as *Action_Name.Q*. For details on action flags, refer to the explanation of *Flags Used to Monitor a Step's Active Status* in *2-3 Elements of SFC*.

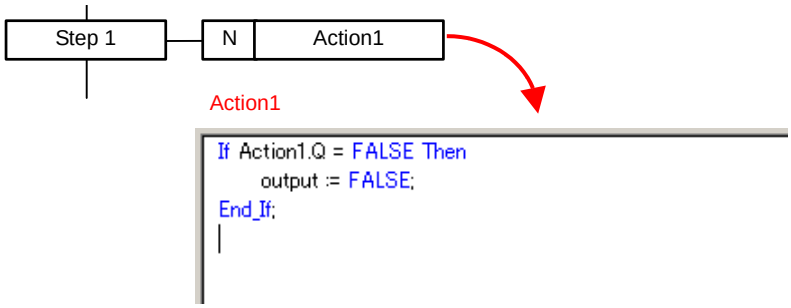
ST Program

With the default setting, the outputs are held.

If you want to reset the outputs, reset the outputs by including an "Action flag = FALSE" condition (see note) in a statement such as an IF statement.

Note: The action flag is ON when the step is active, and OFF when the step is inactive. The flag is written as *Action_Name.Q*. For details on action flags, refer to the explanation of *Flags Used to Monitor a Step's Active Status* in *2-3 Elements of SFC*.

Example:



When step 1 has become inactive, action flag Action1.Q goes OFF, the action flag (Action1.Q) becomes FALSE, and the output goes OFF.

1-5-2 Action Program Precautions

Action Program Execution Sequence

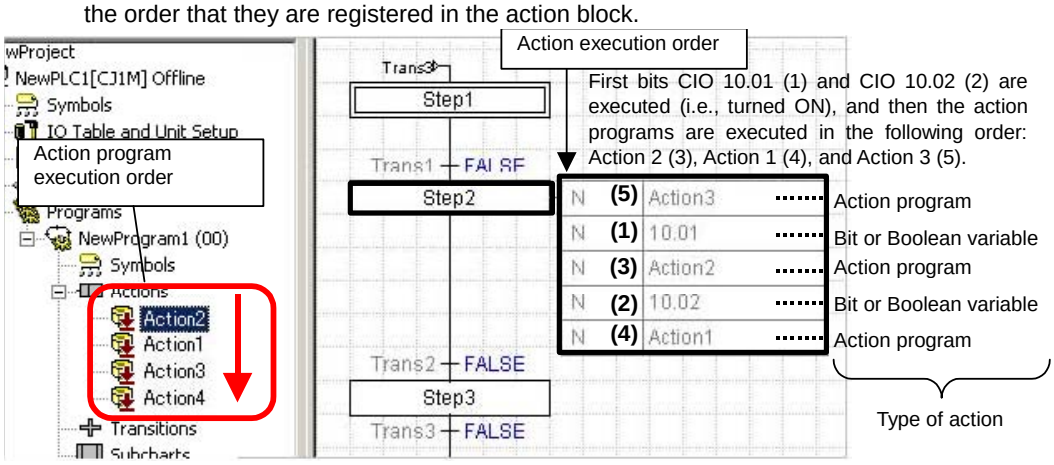
The order of execution for the actions in multiple steps that become active simultaneously within the same SFC execution cycle is as follows:

1. Bits and Boolean variables
2. Action programs
   If multiple action programs become active, they are each executed once each cycle from top down according to their position in the action program tree in the workspace.

Example 1

The execution order for multiple action programs registered in a single step is not according to the order of the action programs next to the step, but rather in the order the action programs are arranged in the workspace.

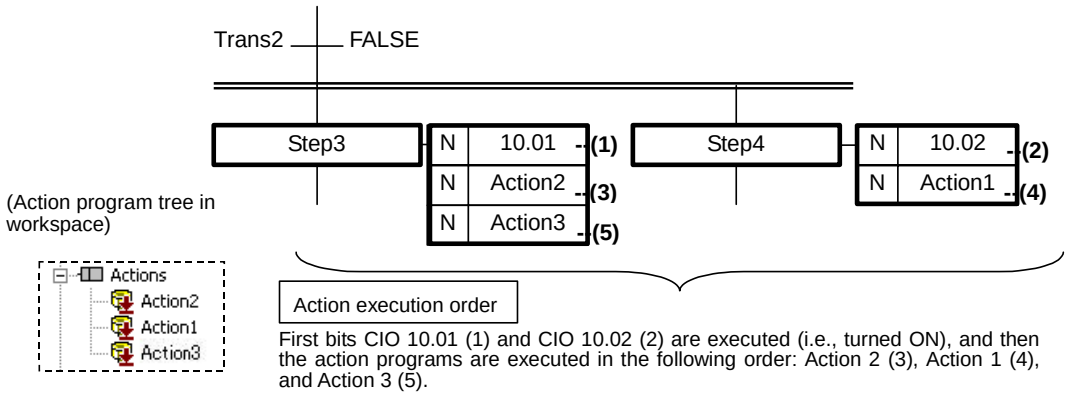
Note: If more than one bit or Boolean variable is registered in an action, they are executed in the order that they are registered in the action block.



Example 2

The execution order for actions in steps that simultaneously become active (e.g., steps 3 and 4) is not by step, but rather bits and Boolean variables are executed first and then action programs.

Note: If more than one bit or Boolean variable is registered in an action, they are executed in the order that they are registered in the action block.



First bits CIO 10.01 (1) and CIO 10.02 (2) are executed (i.e., turned ON), and then the action programs are executed in the following order: Action 2 (3), Action 1 (4), and Action 3 (5).

Note Refer to *2-2 Basic SFC Execution Cycle* for information on the basic SFC execution cycle, including the order of execution for action programs. Refer to *2-3-3 Action Blocks* for information on the execution of action blocks.

Final Scan

Final scan function is an action program execution method defined in the IEC 61131-3 standard. The CX-Programmer conforms to this IEC standard, and is equipped with the final scan function.
The final scan function executes the action program just one more time after the previously executed step becomes inactive, when programming switches to the next step. This final scan function can be used to reset the outputs of the actions that were executed.

Disabling the Final Scan Operation

The final scan function can be enabled and disabled with the following method. Select ***Tools*** - ***Options*** from the menu, click the **SFC** Tab, select the *Use Extended SFC Settings* Option, and select the *Apply Final Scan Logic* Option in the General Tab of the SFC program's properties.

Option selected: Final scan execution is enabled for that entire SFC program.
Option not selected: Final scan execution is disabled for that entire SFC program.

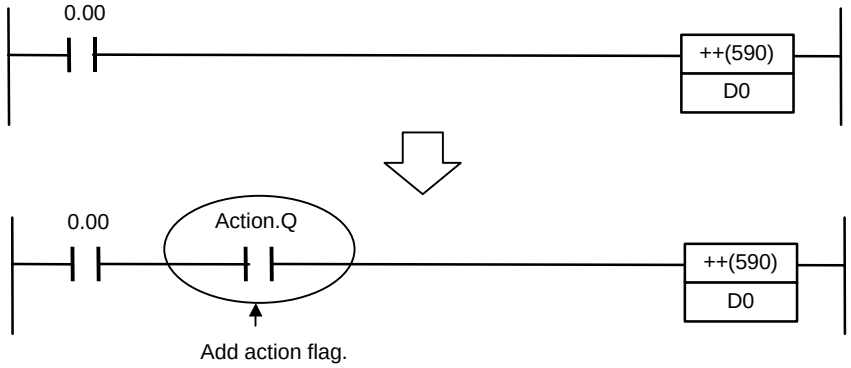
Programming Precautions When Passing Execution Results through a Transition

When the final scan is enabled, the step action will be executed once in the next cycle after the step changes from active to inactive status. Always use the following method to write the action programs in the step before the transition to prevent the final scan from affecting the results when calculation results, such as counter values, from an action in the step before the transition are being evaluated in the step after the transition.

Ladder Programming

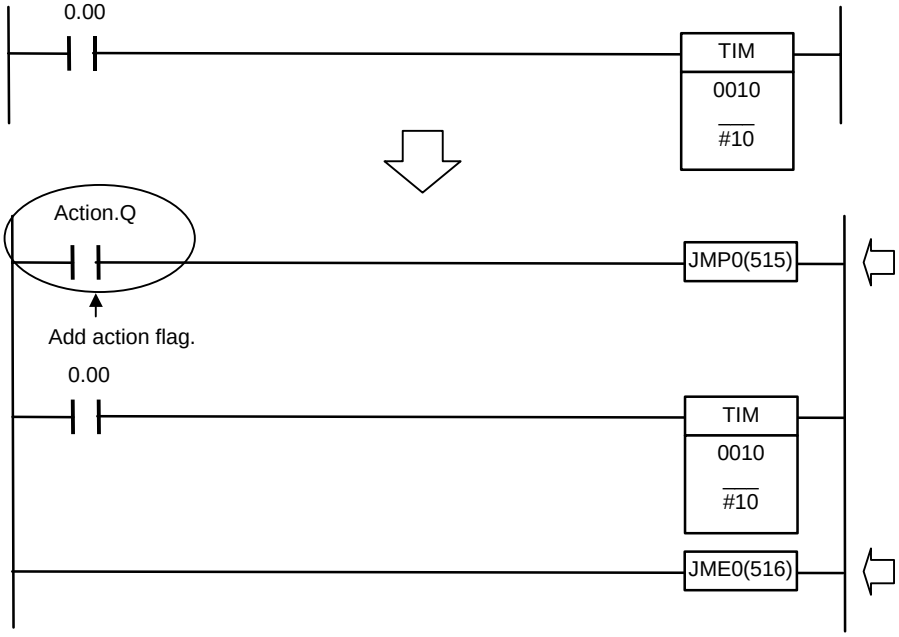
Observe the following precautions if the *Reset Output at Final Scan* Option is deselected (check mark removed) in the ladder program's properties.
When a program section has a calculation that you do not want executed when the step become inactive, always add the action flag as a NO condition for the calculation by ANDing the flag in the execution condition for the calculation.
For details on action flags, refer to the explanation of *Flags Used to Monitor a Step's Active Status* in *2-3 Elements of SFC*.

Example 1



With processing such as the increment processing shown above, add the action flag by ANDing the flag as a NO execution condition. Even if the final scan is executed, the value of D0 will not be incremented in the final scan.

Example 2



When you do not want a timer/counter PV refreshed after the step becomes inactive in timer/counter instruction processing like the processing in the chart shown above, add the action flag by ANDing the flag as a NO execution condition to a JUMP (JMP0) instruction, and enclose the timer/counter instruction between JMP0 and JME0. Even if the final scan is executed, the PV will not be refreshed additionally.

ST Program

Include an “Action flag = FALSE” condition with an AND condition in a statement such as an IF statement, and execute the processing.

1-5-3 Precautions for Transition Programs

A bit output or timer/counter instruction used in a transition program will not be reset when moving to the next step, i.e., operation of the bit output or timer/counter instruction will continue.

1-5-4 Ladder Language Instructions That Cannot Be Used in Action Programs and Transition Programs

The following instructions cannot be used for action programs and transition programs.

Unsupported instructions
Block programming instructions (All instructions, including BPRG and BEND)
Subroutine instructions (SBS, GSBS, RET, MCRO, SBN, GSBN, and GRET)
Jump instructions (JMP, CJP, CJPN, and JME)
Step ladder instructions (STEP and SNXT)
I/O refresh instruction (IORF)
TMHH and TMHHX instructions (except for the CJ1-H-R/CJ2 CPU Units)
Special instructions (FRMCV and TOCV)
Record position manipulation instructions (PUSH, FIFO, LIFO, SETR, and GETR)
Failure point detection Instruction (FPD)
Index register setting instruction (MOVRW)

1-5-5 Task Allocation

SFC programs are assigned to cyclic tasks to use them. (See note.) Refer to *3-1-3 Allocating an SFC Program to a Task* for information on allocating tasks.
Note: Do not use SFC programs in interrupt tasks. They will not execute normally.

Allocating Extra Tasks

The CS/CJ-series PLCs provide 32 cyclic tasks (128 cyclic tasks only for CJ2-series PLCs). In addition to this, up to 256 extra tasks can be used. (Extra tasks are interrupt tasks that are executed each cycle as cyclic tasks.) (See note 1.)
The CX-Programmer can be used to create SFC programs, ladder diagrams, or ST programs in either cyclic tasks or extra tasks. Extra tasks containing SFC programs are started and stopped using the SFCON and SFCOFF instructions from other tasks. (See note 2.) The following numbers are used in the SFCON and SFCOFF instructions to specify the task numbers. Refer to *Appendix B SFC Task Control Instruction Specifications* for specifying methods.

Task	Number
Extra task 0 (interrupt task 0)	8000
Extra task 1 (power OFF task)	8001
Extra task 2 (scheduled interrupt task 1)	8002
Extra task 3 (scheduled interrupt task 2)	8003
Extra tasks 4 to 99 (interrupt tasks 4 to 99)	8004 to 8099
Extra tasks 100 to 131 (I/O interrupt tasks)	8100 to 8131
Extra tasks 132 to 255 (interrupt tasks 132 to 255)	8132 to 8255

Note 1. When using extra tasks, be sure to refer to the *CJ2H Programmable Controllers Software User's Manual* (Cat. No. W473) and the *CS/CJ/NSJ Programming Manual* (Cat. No. W394) and confirm application methods. If the conditions to execute extra tasks as interrupt tasks are met, the task will not execute normally.

2. Do not use the TKON and TKOFF instructions to stop and start tasks with SFC programs. The instructions will not function normally.

1-5-6 Memory Allocation

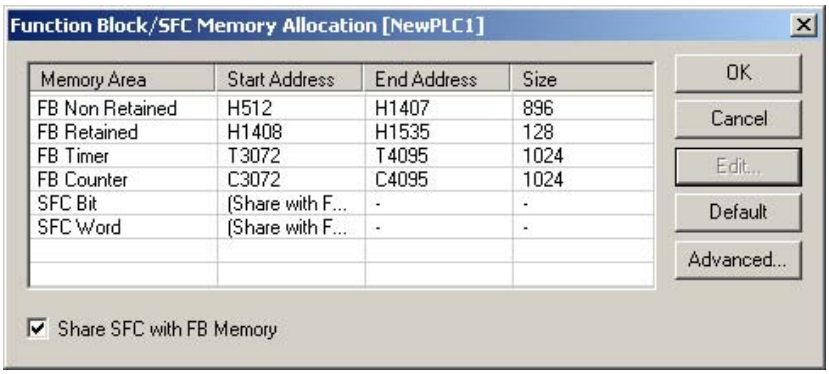
In CX-Programmer, the system allocates memory automatically to steps, transitions, and actions. With the factory default setting, the “FB Non Retain” memory area (H512 and later) of the function block will be allocated.
This memory area may be insufficient, however, for larger SFC programs. In this case, use the “SFC bit” and “SFC word” memory areas for SFC.
When using the “SFC bit” and “SFC word” memory areas for SFC, uncheck the ***Share SFC with FB Memory*** checkbox.

Memory Area	Default Value			Allocable Area
	First Address	End Address	Size	
FB Non Retain	H512	H1407	896	CIO, WR, HR, DM, EM
FB Retain	H1408	H1535	128	HR, DM, EM
FB Timer	T3072	T4095	1024	TIM
FB Counter	C3072	C4095	1024	CNT
SFC Bit	N/A	N/A	N/A	-
SFC Word	N/A	N/A	N/A	-

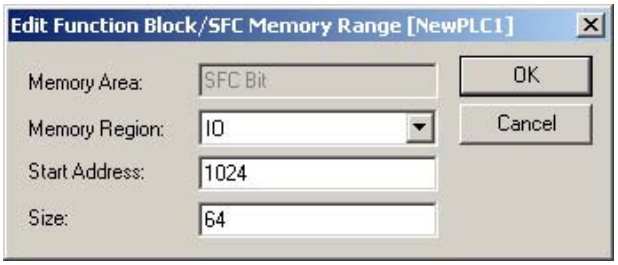
Note: DM or EM can be used for the "FB Non Retain" memory area. Uncheck the ***Share SFC with FB Memory*** checkbox, since neither DM nor EM can be used as memory areas for SFC.

Setting Procedure

1 Select ***Memory Allocation – Function Block/SFC Memory – Function Block/SFC Memory Allocation*** from the PLC menu.
The Function Block/SFC Memory Allocation Dialog Box will be displayed.
2 Uncheck the ***Share SFC with FB Memory*** checkbox.



3 Select ***SFC Bit*** or ***SFC Word***.
4 Click the **Edit** Button in the Function Block/SFC Memory Allocation Dialog Box.
The Edit Function Block/SFC Memory Range Dialog Box will be displayed.



5 Select *Memory Area* and input *First Address* and *Size*.
6 Click the **OK** Button in the Edit Function Block/SFC Memory Range Dialog Box.
7 Click the **OK** Button in the Function Block/SFC Memory Allocation Dialog Box.

Note: Set the memory areas for both "SFC bit” and “SFC word”.

1-5-7 Subchart Online Editing Function Restrictions

Subcharts cannot be edited during online editing.

SECTION 2
SFC Fundamentals

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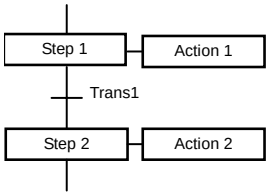
2-1 SFC Basic Operation

This section describes the behavior of an SFC program using a basic step progression control.

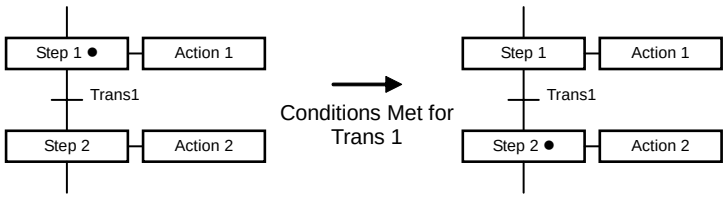
Step Progression Control

Step progression control is a method of program control in which the execution of each step, consisting of an entire process, is sequential or time-dependant.
SFC is a graphical programming language developed to allow step progression control to be easily implemented. Step Ladder has been widely used as a language for describing step progression control, but SFC has visual properties superior to traditional Step Ladder.
Consider the following example: “Execute Process 1 until Condition A is met, then stop Process 1 and execute Process 2”. The following shows the behavior of an SFC program using basic step progression control (Process 1 is executed and, if condition A is met, process 2 is executed) as an example.



Assign Process 1 to Action 1.
Assign Process 2 to Action 2.
Assign Condition A, the transition condition between steps, to Trans 1.

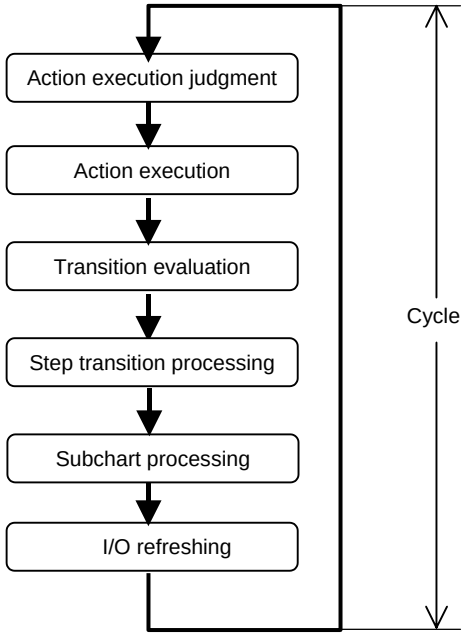
A step is either active or inactive.
An active step executes the actions defined in that step.
If the condition for the step to transfer to the next step is met, then the immediately preceding step becomes inactive and the immediately succeeding step becomes active.
The following illustrates that the transition condition, "Trans1" is met and that the active status has transferred from step 1 to step 2.
The step showing "●" is the active step.



All the actions within an active step are executed for at least one cycle, even if the condition for the step to transfer to the next step has been met (Note, however, that the execution of some actions may be prevented by AQs).

2-2 Basic SFC Execution Cycle

The following processing is performed in the SFC execution cycle as 1 unit for all active steps. No processing is performed for inactive steps.



- Action execution judgment

The results of the previous cycle's step transition processing is received, and the AQ (action qualifier) is read to determine whether or not the all of actions will be executed. When a Boolean bit is specified in the action, the action is executed based on the result of the action execution judgment. When multiple Boolean bits are specified in a single step, they are executed in the order (from top to bottom) that they appear in the action block. If active status has changed since the previous cycle, final scan processing (see note) is performed for any action programs in steps that have changed to inactive status.

Note: Refer to *1-5-2 Action Program Precautions* for information on the final scan operation.

- Action execution

When a step is active, the action programs written in the step are executed in the following order, including actions in subcharts, based on the result of the action execution judgment.

- First, all actions for which Boolean variables are specified are executed according to the action execution judgment. Then action programs are executed. For information on the execution order of action programs, refer to *1-5-2 Action Program Precautions*.
- When the same action program is specified in two or more steps that are active at the same time, that action program will be executed just once in a cycle.

- Transition evaluation

The transition conditions of active steps are evaluated. The transition program connected after the active step is executed at this time.

- Step transition processing

The current step is switched to inactive status and the next step is switched to active status if the transition evaluation determined to move to the next step.

Note 1: The status is switched even if the next step is active (see note 2). If you do not want the status to switch, add a transition condition that checks whether or not the next step is active.

Note 2: SFC operation is different in the CV-series PLCs. In the CV-series PLCs, the status is not switched if the next step is active.

- Subchart processing

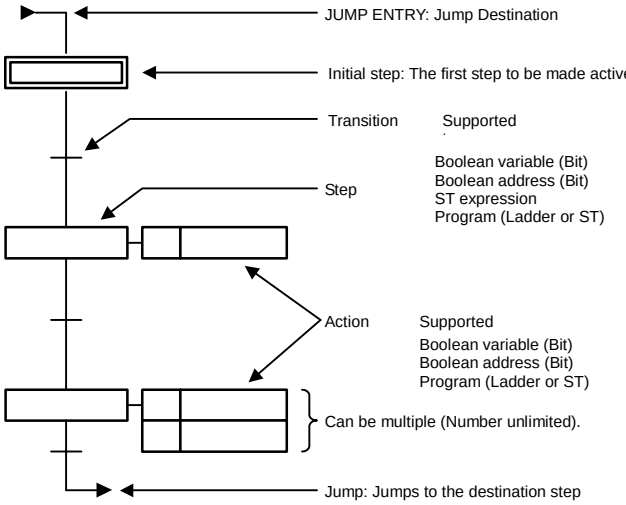
The subchart is executed if the subchart step is active. Subcharts are processed in the following order:

1. Subchart initialization
2. Transition evaluations inside the subchart
3. Step transition processing inside the subchart
4. Processing to return from the subchart

Note: Actions inside a subchart are executed at the same timing as previously described in *Action Execution.* If more than one subchart is active at the same time, the subcharts are executed from top down in the order the subcharts are arranged in the workspace.

2-3 Elements of SFC

This section explains the element of SFC.



2-3-1 Steps

A step is an element of an SFC program and represents a single process within an entire process.

Operation of Steps

A step is either active or inactive.
An active step executes the actions defined in that step, while an inactive step does not execute any actions until it becomes active.
The step status transfers when the transition condition is met, but the transfer actually depends the status of the step before the transition as well as the transition condition.
The status of steps transfers when all of the following conditions are met.

● Step Transfer Condition

1	All transition conditions have been met.
2	All steps before the transition point are in the active status.

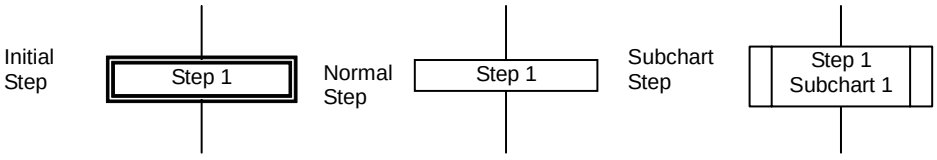
Note: The step transfers even if the connecting step after the transition is active.

Some steps do not have an action to execute. These steps will remain in the waiting status, with no processing to perform until the transition conditions are met.
Steps, which do not have an action to execute, are referred to as “dummy steps”.

Step Types

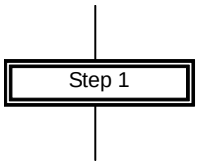
There are following types of steps:

- Initial step
- Normal step
- Subchart step



Initial Step

An initial step is the step that unconditionally becomes active upon program execution start. All other steps are inactive at this moment.
It is also the first step to be executed in the SFC chart.
When the initial step becomes active, the actions defined in the initial step are executed.
The initial step is represented as shown below.

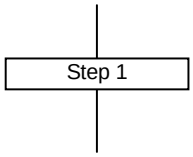


- Only one initial step can be created within an SFC chart.
- The initial step does not necessarily need to be positioned at the head of the program.
- An initial step can hold one or many action blocks.
- When the initial step becomes active, action blocks assigned to the step are executed.

If the power supply is turned OFF during SFC program execution. The program will be executed from the initial step when the power supply is turned back ON. To perform initialization when continuing operation or to select the steps with the step control instructions to continue step operation, include status control programming in the initial step.

Normal Step

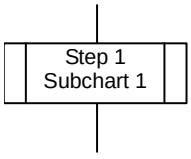
A normal step is the step that becomes active if the transition condition is met.
When the step becomes active, the actions defined in the normal step are executed.
The normal step is represented as shown below.



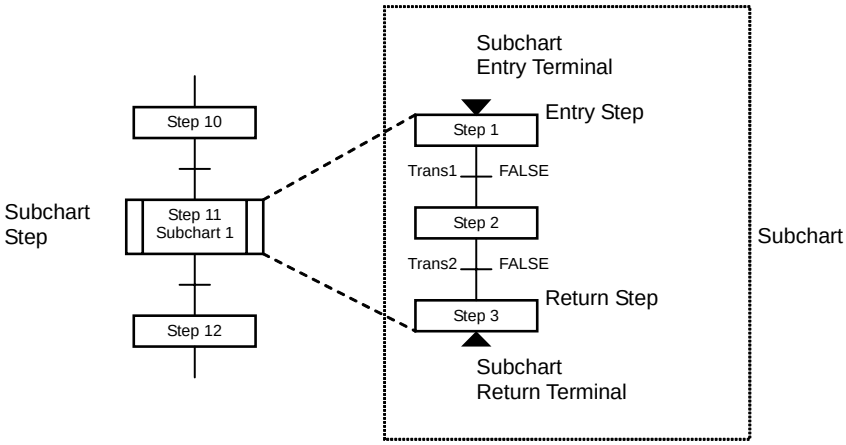
- There is no limit on the number of normal steps used within an SFC chart.
- A normal step can hold one or many action blocks.
- When a normal step becomes active, action blocks assigned to the step are executed.

Subchart Step

A subchart step is the step that calls up the subordinate SFC chart (subchart) from an SFC chart.
The subchart step is represented as shown below.



A subchart is the macro expansion of an SFC step into a group of SFC programs, similar to the subroutine of a conventional programming language.



A subchart is called up by a subchart step. Its execution begins at the subchart entry terminal, and returns to the main process flow at the subchart return terminal.

- There is no limit on the number of subchart steps used within an SFC chart.
- If the transition conditions (for the downside transition) are met while a subchart step is active, the active status is not transferred to the next subchart step until the SFC within the subchart reaches its return step.
- The processing of a subchart always begins at the subchart entry terminal (▼) and ends at the subchart return terminal (▲).
- When the return step becomes active, it will remain active until the active status is transferred for the parent subchart.
- Each subchart requires one entry step and one or more return steps. There is no limit on the number of return steps within a subchart.
- A subchart can call up another subchart.
  There is no limit on the subchart layers.
- When the return step becomes active and the subchart is terminated, all other active steps within the subchart are simultaneously terminated.
- A subchart step does not hold any action.
- A single subchart can be called up by multiple subchart steps. When two subchart steps attempt to call up the same subchart, however, the latter caller must wait until subchart execution is completed for the former caller.

Step Control Instructions

Step control instructions (SA, SE, TSR, TSW) can be used to control SFC steps.
SA: Activate step (Switches a step to the activate status)
SE: Deactivate step (Switches a step to the inactivate status)
TSR: Read step timer value instruction (Reads the present value of the step timer)
TSW: Set step timer value instruction (Updates the present value of the step timer)

In each of the instructions, the step flag is specified as follows:

- For within the same task [step name].X

For within another task [program name].[step name].X

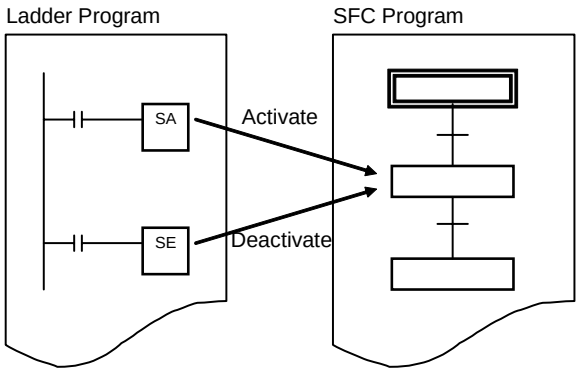
In each of the instructions, the step timer is specified as follows:

- For a step within the same task [step name].T
- For a step within another task [program name].[step name].T
- For a subchart step within the same task [subchart name].[step name].T
- For a subchart step within another task [program name].[subchart name].[step name].T

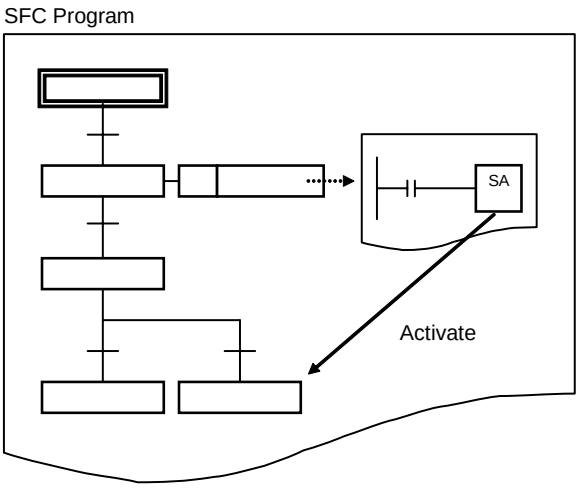
For details on step flags, refer to the following description under *Flags Used to Monitor a Step's Active Status.*

Step activation/deactivation instructions can be used for the following purposes.

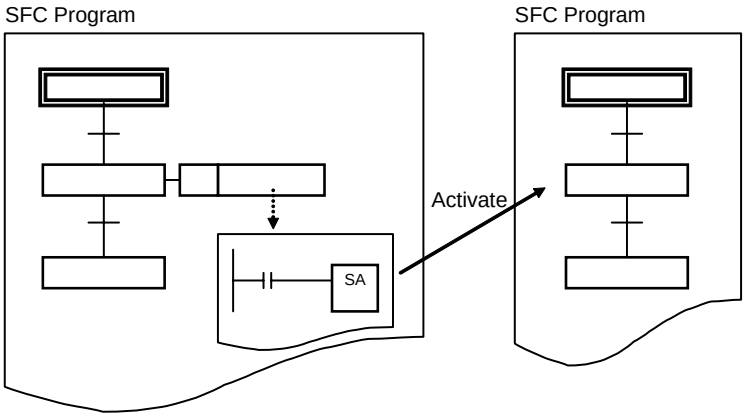
Controlling a Step in an SFC Program from an External Ladder Program



Controlling a Step in an SFC Program from an Action Ladder Program within the Same SFC Program



Controlling an SFC Step from an Action Ladder Program within Another SFC Program



Note: If the SA step control instruction is used to activate another step in the same SFC program from an action ladder program in the SFC program, the activated step's action will be executed in the next cycle.

If the SA step control instruction is used to activate a step in a different SFC program from an action ladder program in the SFC program, the activated step's action will be executed in the current or in the next cycle, depending on the order of the SFC program execution task numbers.

- If the SFC program containing the step activated with the SA step control instruction has already been executed, the activated step will be executed in the next cycle.
- If the SFC program containing the step activated with the SA step control instruction has not yet been executed, the activated step will be executed in the same cycle.

Step timer value read/set instructions can be used in the same way as step activation/deactivation instructions.

- A step can have a step timer to maintain the time, which has elapsed since the step became active. For each step, the time unit on the step timer can be set to either of the following:

    - 100 milliseconds
    - 1 second
- The first operand time range for a step timer value instruction reading varies, according to the time unit of the specified step timer, as follows.
    - 100 milliseconds 0 to 6553.5 seconds
    - 1 second 0 to 65535 seconds
- Actions with the action qualifier D, DS, or L are executed in synchronization with the step timer. Caution should therefore be exercised when making changes to the step timer of a step, which has those action qualifiers in its actions.
- When the step becomes inactive, the step timer is stopped, and the elapsed time data is saved. The step timer is reset when the step becomes active again.
- When the step timer value reaches the upper limit, the timer will stop and maintain the maximum value.

For detailed specifications of step control instructions, refer to Appendix A – *Specifications for Step Control Instructions*.

Precautions on Subcharts

Executing the SA Step Control Instruction for a Subchart Step

When the SA step control instruction is executed for a subchart step, that subchart step will become active, and the subchart will operate from the entry step.

Executing the SE Step Control Instruction for a Subchart Step

When the SE step control instruction is executed for a subchart step, that subchart step will become inactive, and the subchart's operation will stop. (Active steps in the subchart will become inactive.)

Using the SA and SE Step Control Instructions in a Subchart Step

The SA and SE Step Control Instructions cannot be used for a step in the same subchart.

Note: SFC operation is different in the CV-series PLCs. In the CV-series PLCs, subchart steps can be used in instruction operands.

Operation When Multiple Subchart Steps Calling the Same Subchart Are Active

- When a given subchart step is active, another subchart step calling the same subchart can become active by a status transition or execution of the SA instruction (see note). In this case, the subchart's current execution status will not change. Execution of the subchart for any other subchart steps will standby until the subchart step that first called the subchart becomes inactive.
- If the subchart step for which the subchart is currently being executed changes to inactive status or the subchart step is deactivated with the SE instruction, the subchart will be executed again from the entry step for any other subchart step that was in standby status.
- If a subchart is currently being executed for one subchart step and another subchart step calling the same subchart changes to inactive status or the subchart is deactivated with the SE instruction, the subchart execution will continue as long as the subchart step for which the subchart is currently being executed is still active.

Note: SFC operation is different in the CV-series PLCs.
In the CV-series PLCs, if a given subchart step is active, another subchart step calling the same subchart cannot become active by a status transition or execution of a step control instruction. In this case, execution of the previous step continues, and the step goes into standby status.

- When multiple subchart steps are in standby status, the subchart that is executed next is determined by the order in which the subchart steps are registered.
The execution order can be confirmed in the Action Used List Dialog Box. Refer to *Checking Action Usage* under *2-3-3 Action Blocks*.

Flags Used to Monitor a Step's Active Status

Step Flags
These flags indicate the steps active/inactive status.
The flags are expressed as *Step_name.X*, and each flag will be ON when the corresponding step is active or OFF when the corresponding step is inactive.

Step Timers
These timers indicate how long each step has been active.
The timers are expressed as *StepName.T*, and the timer's units can be set to 100 ms or 1 s units for each step.

Procedures:

Adding a Step
Right-click a transition, and select ***Add Step***.

Defining the Initial Step
To convert a normal step to an initial step, right-click the normal step, and select ***Step Type*** - ***Initial***.

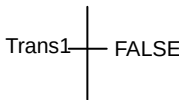
Adding a Subchart Step
Right-click a transition, and select ***Add Subchart Step*** - ***New Subchart***.

Defining a Subchart
Right-click a *Subcharts* folder in the project workspace, and select ***Insert SFC Subchart***.

Administering a Step Control Instruction
Input the instruction as a regular ladder instruction, and specify the target step flag.

2-3-2 Transitions

A transition represents the condition in which the active status transfers from the step before the transition to the step after it. One transition must be set between steps.
The transition is represented as shown below.



Operation of Transitions

When the transition condition is met, the step before the transition becomes inactive and the step after it becomes active.
In this way, the transition controls the program flow from step to step.

- When representing transition conditions with transition programs, turning a transition program name ON will turn the represented transition condition ON.

Transition Conditions

Transition conditions are to be defined on the right-hand side of the figure.
When a transition is added to the SFC editor, its default condition is the ST expression "FALSE".
The condition equation for a transition can be set to any one of the following:

- Bit (Boolean variable or actual address)
- ST expression
- Transition program name

Boolean Action (Bit)

Boolean Variable

A transition condition can be defined using a Boolean variable name.
Example: In the case of “bFlag”, the condition is met when “bFlag” is ON.

Actual Address (Bit)

A transition’s condition can be defined using an actual address (bit).

ST Expression

A transition condition can be defined using an ST expression.
Formats for ST-programmed condition equations are listed below:

Formats for Boolean Variables in Defining Transitions with ST Expressions

Operator Name	Operator	Example	Details
Parenthesis	()	(a & b) OR c	Condition met if both “a” and “b” are ON, or if “c” is ON
Complement	NOT	NOT bFlag	Condition met if bFlag is OFF
AND	AND, &	a & b	Condition met if both “a” and “b” are ON
Exclusive OR	XOR	a XOR b	Condition met if “a” differs from “b”
OR	OR	a OR b	Condition met if “a” or “b” is ON
Equality	=	a = b	Condition met if “a” and “b” are the same

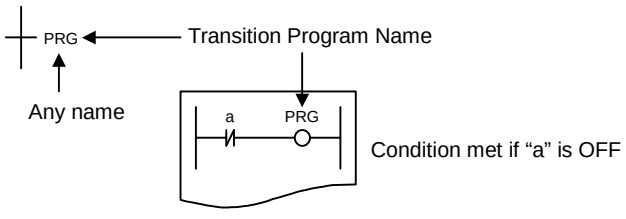
Formats for INT, DINT, LINT, UINT, UDINT, ULINT, CHANNEL, REAL, LREAL, WORD, DWORD, LWORD, UINT_BCD, UDINT_BCD, and ULINT_BCD Variables in Defining Transitions with ST Expressions

Operator Name	Operator	Example	Details
Parenthesis	()	(nValue = 10) & a	Condition met if nValue is 10 and “a” is ON
Comparison	<, >, <=, >=	nValue >= 10	Condition met if nValue is 10 or greater
Equality	=	nValue = 10	Condition met if nValue is 10
Inequality	<>	nValue <> 10	Condition met if nValue is not 10

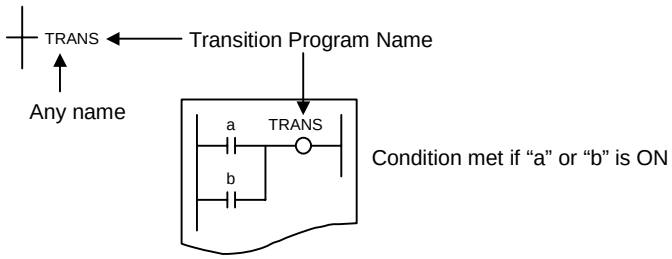
Transition Program

Program names may be used as transition conditions.
A transition program can be coded using either Ladder or ST as the language.
In CX-Programmer, a transition condition is met when the Boolean variable with the same name as the transition program is switched to “ON”.

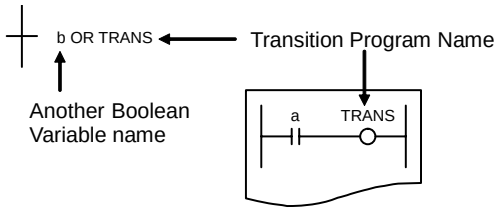
Example 1: “b” bit for “a”



Example 2: OR bits for “a” and “b”



When a transition program is used as a transition condition, specify a transition program name for the transition condition. If a conditional equation is specified with a different Boolean variable name, than that of transition program name for the transition condition, the program will not run properly.



The condition of a Boolean output that was used inside a transition program is also retained after moving to the next step.

Ladder Program

Some instructions are not supported when defining a transition program in ladder logic. For details, refer to *1-5-4 Ladder Language Instructions That Can Not Be Used in Action Programs and Transition Programs*.
Do not use timer instructions in a transition program. A timer that has timed out cannot be reset in a transition program.
An END instruction is not required at the end of a ladder transition program.

ST Program

For specifications on the ST language used when defining transition programs in ST, refer to *Part 2: Structured Text (ST)* in the *CX-Programmer Operation Manual Function Blocks/Structured Text* (Cat. No. W447).

Procedures:

Adding a Transition

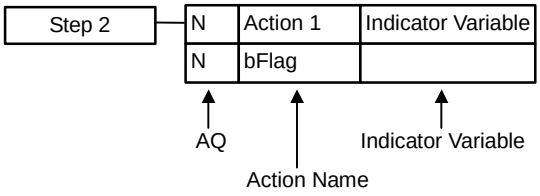
Right-click a step, and select ***Add Transition***.

2-3-3 Action Blocks

An action block is used to program the processes for a step.
A single step can register multiple action blocks.
An action within an action block can have the following information registered.

- Action Qualifier (AQ)
- Action name
- Indicator Variable

An Action block is represented as shown below. In the following figure, action qualifier (AQ), action name, and indicator variable are illustrated, from left to right.



- An action block is inserted into a single step.
- There is no limit on the number of actions registered with an action block.

Administering Action Blocks

When a step becomes active, all actions in its action block are executed according to the conditions set by the action qualifier.
While a step is in the active status, each action in its action block is executed once each cycle. During a cycle, action blocks are executed in sequence, from top to bottom, when Boolean bits are specified. With action programs, the programs are executed in sequence after execution of the Boolean bit actions, and the sequence is from top to bottom, in the order that they appear in the project workspace.

Action Qualifier (AQ)

AQ defines the execution timing for each action.
It can determine how the actions should be executed when the step becomes active.
Only one AQ can be specified for each action.
The action's type determines whether the outputs are held or reset when the step goes from active to inactive status. When necessary, change the initial settings or add reset processing to the program.

- When a bit is specified, the output is reset when a holding action qualifier (S) is not specified. The output status is held if a holding action qualifier is specified.
- With ladder programs, the outputs are reset by default. The default setting can be changed to hold the output's status.
- With ST programs, the status of the outputs in the program is held by default. When necessary, write reset processing in the program and use the Action Flag (a flag that goes ON when the corresponding step in an ST program becomes inactive) to control the reset processing.

Note: For details, refer to *1-5-1 Holding or Resetting an Action's Outputs*.

Types of Action Qualifiers (AQs)

There are 11 AQ types, as follows. D, DS, L, SD, and SL have a time element.
For functions and for time element availability of the 11 AQ types, refer to the following table.

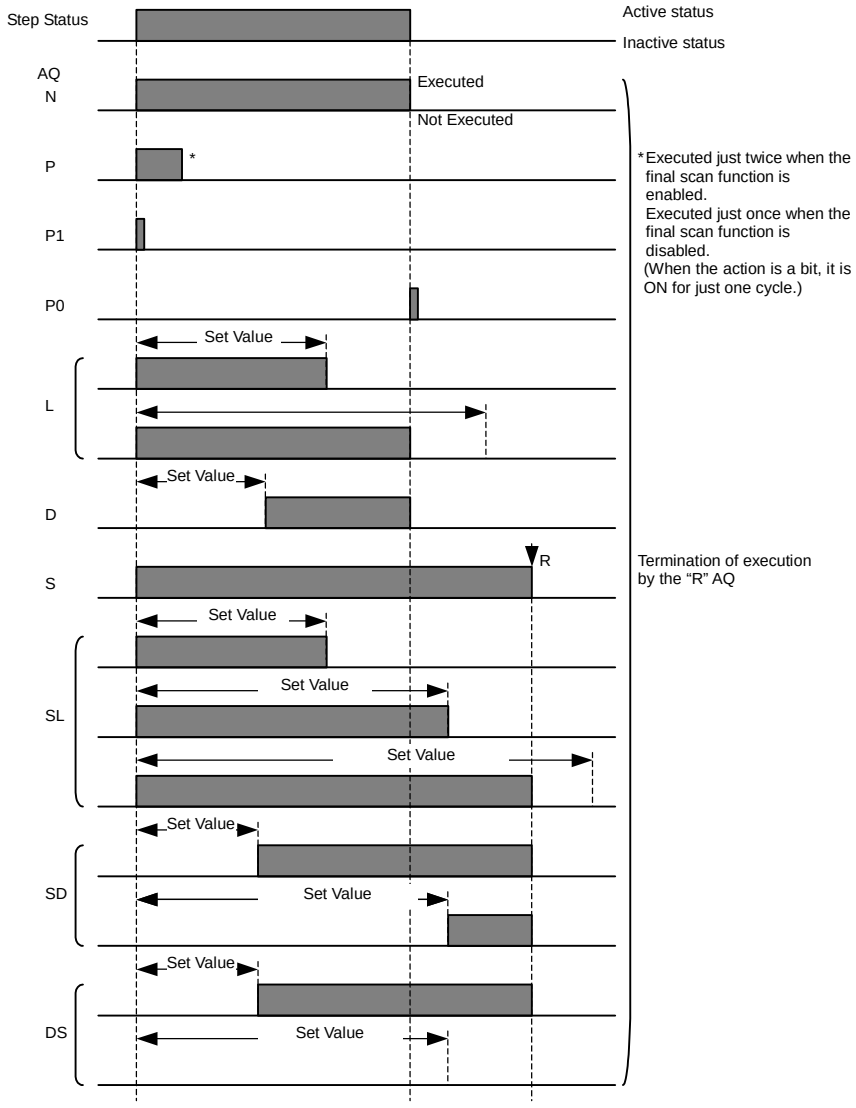
AQ List

AQ Symbol	Name	Function	Timer Set Required?
D	Delay	The action is executed after the user-specified time has passed, since step activation. If the step becomes inactive before the user-specified time expires, the action will not be executed.	Yes
DS	Delay SET	Carries out the same operation as "SD". In contrast to "SD", the action will not be performed if the step becomes inactive before the user-specified delay time expires. To cancel the execution, use the "R" AQ.	Yes
L	Limit	When the step becomes active, the action is executed until the user-specified time expires. Should the step become inactive, execution of the action will be terminated.	Yes
N	Normal (Default)	The action is executed for as long as the step is active.	

P	Pulse	If the final scan function is enabled, the action is executed for two cycles when the step becomes active. If the final scan function is disabled, the action is executed for only one cycle when the step becomes active.	
P1	Rising Pulse	The action is executed once, each time the step becomes active.	
P0	Falling Pulse	The action is executed once, each time the step becomes inactive.	
R	Reset	When a step becomes active, and its action is being executed by the "S", "SL", "SD", or "DS" AQ, the specified action is stopped and reset. If the action is being executed, but not by the "S", "SL", "SD", or "DS" AQ, then the action is only reset (not stopped). The reset operation sets the following: OUT/OUT NOT instruction: “OFF”; TIM/TIMH instruction: “Reset”; Other Timer/Counter/Shift registers: “Hold”.	
S	Set	The action is executed when the step becomes active, and continues to be executed, even after the step becomes inactive. To cancel the execution, use the “R” AQ.	
SD	Set Delay	The action is executed after the user-specified time has passed, since step activation, and continues to be executed, even after the step becomes inactive. To cancel the execution, use the “R” AQ.	Yes
SL	Set Limit	The action is executed when the step becomes active, and until the user-specified time expires. In contrast to “L”, the action continues to be executed even after the step becomes inactive. To cancel the execution, use the “R” AQ.	Yes

The timer set value is a setting used by AQs, which require a time element.
Timer set value is required by the following AQs:
D, DS, L, SD, SL
D, DS, and L control the timing of action execution, using the step timer. The time unit on the timer is the same as that on the step timer for the step to which the action block is allocated.
SD and SL control the time using a different timer than the step timer, since they operate independently of step status.

Action Execution Timing for Action Qualifiers (AQs)



Actions

An action is executed when a step changes to the active status. Actions can be specified as either of the following:

- Bit (Boolean variable or actual address)
- Action program name

When an action is defined as a Boolean variable (bit), the bit is turned ON when the action is executed, and turned OFF when the action is stopped.

When an action is defined as an action program name, the action program is executed when the action is executed, and stopped when the action is stopped.

Note: Multiple steps can run the same action program within a single execution of the SFC. Only simultaneously activated steps are affected by single scan execution.

Boolean Variable or Actual Address (Bit)

An action block can be defined as a Boolean variable or actual address (bit). When the step becomes active, the Boolean variable or actual address (bit) is turned ON according to the AQ, and the bit is turned OFF if the action stops.

Action Program

If the action is executed, the specified action program is executed.

Note: The same action program can be specified in multiple steps of an SFC chart. When two or more steps are active at the same time and have the same action program specified, that action program is executed just once in a cycle.

An action program can be coded using either Ladder or ST as the language.

Ladder Program

An action block can be defined as a ladder program.
Some instructions are not supported when defining an action program in ladder logic. For details, refer to *1-5-4 Ladder Language Instructions Can Not Be Used in Action Programs and Transition Programs*.
In ladder programs, the *Reset Output at Final Scan* Option can be selected in the action's properties to turn OFF the ladder program's outputs when the step is inactive. If function blocks are used in the ladder program, the status of outputs used in the function blocks will be held.

Note: If the action qualifier is set to "N", the ladder program may not be able to correctly detect the step "rising" to the active status. For this reason, if a process is to be executed only once, upon the activation of the step, the "P1" action qualifier should be used.

ST Program

An action block can be defined as an ST program.
For specifications on the ST language used when defining transition programs in ST, refer to *Part 2: Structured Text (ST)* in the *CX-Programmer Operation Manual Function Blocks/Structured Text* (Cat. No. W447).

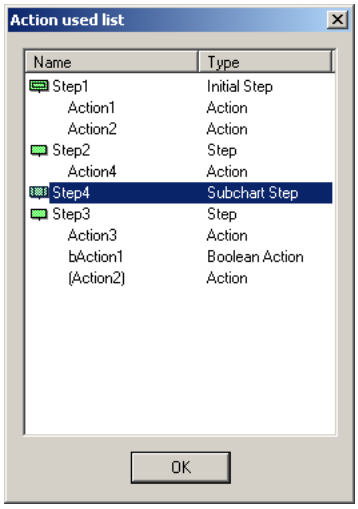
Action Execution Order

Refer to *1-5-2 on Action Program Precautions* for information on the order of execution of actions within a step and the actions within multiple active steps.

Checking Action Usage

It is possible to display a list of all of the actions (Boolean bit specifications and action programs) in a single SFC program.
Select Program – Action used list. The following dialog box will be displayed, so that the use of the actions can be checked.

- Selecting the Main SFC



- Selecting a Subchart

- Steps are displayed from the top in the order in which they are registered. Multiple active subcharts are executed in the order in which they are registered, i.e., from top down as they are displayed in the dialog box.

- If an action is used in more than one step, it will be displayed in parentheses from the second occurrence on to indicate that it is used more than once.

Flags Indicating the Execution Status of Actions

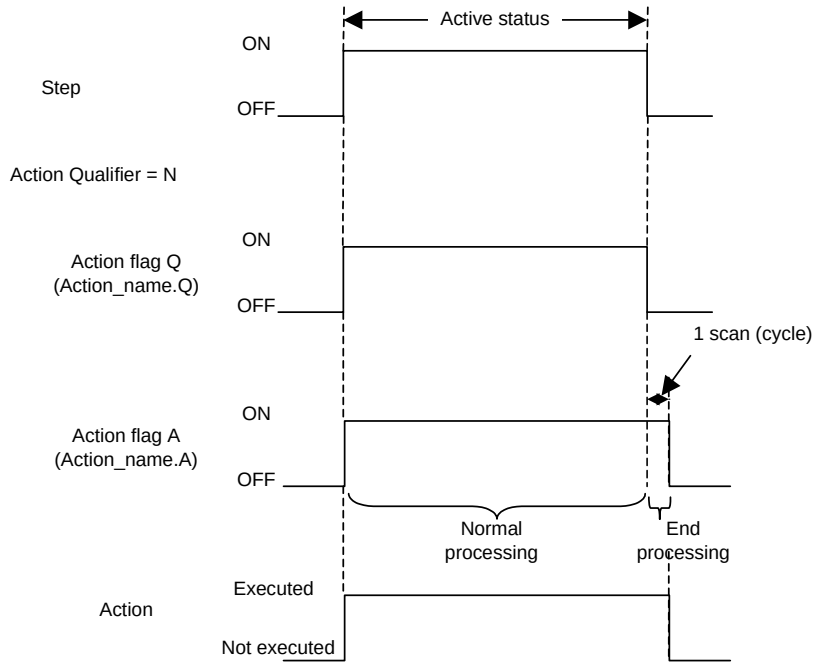
There are two kinds of flags that indicate an action's execution status. Both kinds of flags are changed by the step's active/inactive status, and both can be used as bits in ladder and ST programs.

Action Flag Q (Action_name.Q)
This flag is ON when the step is active, and goes OFF when the step is inactive. This flag can be used as an input condition in a ladder or ST program to prevent execution of a process when a step is deactivated. The flag can also be used as an input condition in an ST program when resetting outputs.

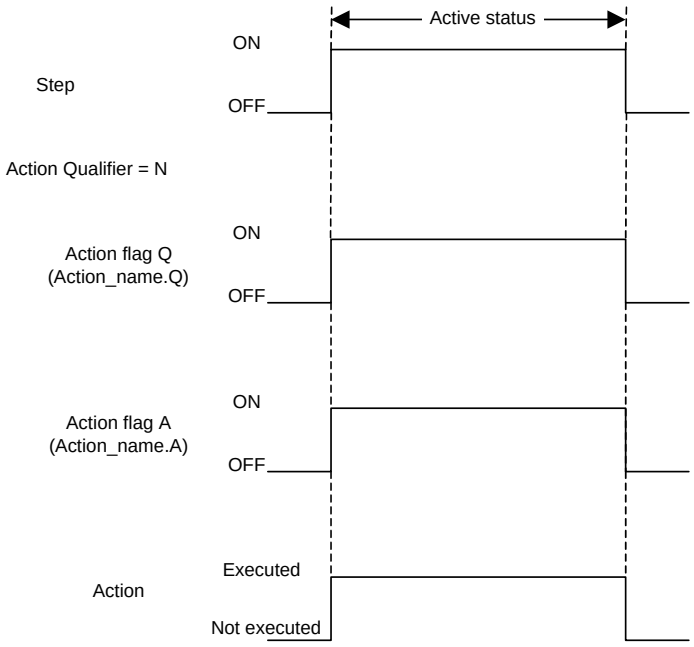
Action Flag A (Action_name.A)
This flag is ON when the step is active, and goes OFF when execution of the final scan is completed after the step is deactivated.

Use the Action Flag A as a set with the Action Flag Q when special processing must be performed for the final scan in a ladder or ST program.

The following diagram shows the operation of the action flags when the final scan function was enabled by selecting the *Apply Final Scan Logic* Option in the General Tab of the SFC program's Property Dialog Box.



The following diagram shows the operation of the action flags when the final scan function was disabled by clearing the *Apply Final Scan Logic* Option on the General Tab Page of the SFC program's Property Dialog Box.



Indicator Variable

A variable name can be registered to represent an action. Nothing will be executed, however.

Procedures:

Adding an Action

Right-click a step and select one of the following from ***Add Action - Boolean Action***, ***New Ladder Action***, ***New Structured Text Action***, ***Existing Action***.

Selecting an AQ

Double-click an AQ in an action block, and select from the combo list.

Changing the Time Set Value for an AQ

Right-click an action block, and select ***Edit Action Qualifier Time***.

Adding a Boolean Variable

Directly input the name of a Boolean variable as the action name. Or, double-click the right-hand side of an action block, click the [▾] on the right, and select a registered variable name. Clicking [▾] will display all local variables registered in the variables table.

Defining an Action Program

Right-click the *Actions* folder in the project workspace, and select either ***Ladder*** or ***Structured Text***, both under ***Insert Action***.

Adding a Ladder Program

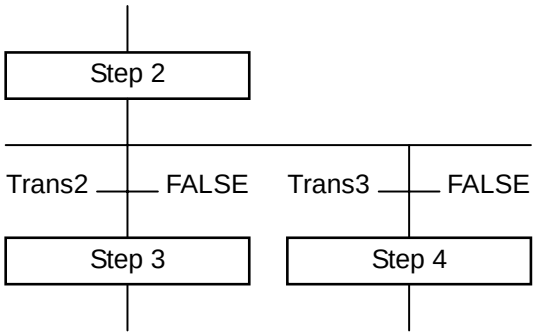
Right-click a step and select ***Add Action*** - ***New Ladder Action***, or (if an action program is already registered) select ***Existing Action*** to use an existing action program.

Adding an ST Program

Right-click a step and select ***Add Action*** - ***New Structured Text Action***, or (if an action program is already registered) select ***Existing Action*** to use an existing action program.

2-3-4 Divergences

A divergence is a program control structure for SFC, in which two or more transitions are connected after a single step.
A divergence is represented by a single horizontal line.
With a divergence, the process flow branches from a single step to two or more steps, and active status is transferred for the branch on which the transition conditions are met.



Administering Divergences

If a step before a divergence is in the active status and one of the transition conditions after that divergence is met, the active status will be transferred, provided that the step after the transition is currently in the inactive status.

- If multiple transition conditions at a divergence are simultaneously met, priority will be given to the left-most step. (Transition at a divergence can only take place for one step.)
  If the priority of the steps has been changed, however, active status will be transferred according to the priority order.

Procedures:

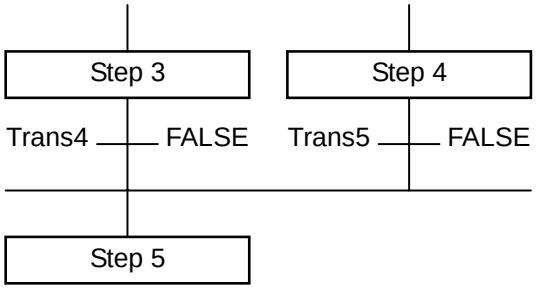
Adding a Divergence

Right-click a step and select ***Add Divergence***. To make a divergence with three or more branches, right-click an existing divergence, and select ***Add Divergent Transition Branch*** to add a branch.

Note: Right-click the divergence and clear the selection of the ***Use Default Transition Precedence*** to display the execution order numerically, starting from 1. The order of execution can be specified freely by double-clicking a corresponding number and changing it.

2-3-5 Convergences

A convergence is a program control structure for SFC, in which a single step is connected after two or more transitions.
A convergence is represented by a single horizontal line.
A convergence merges a process flow, which has been split into two or more process flows (i.e. by a divergence).



Administering Convergences

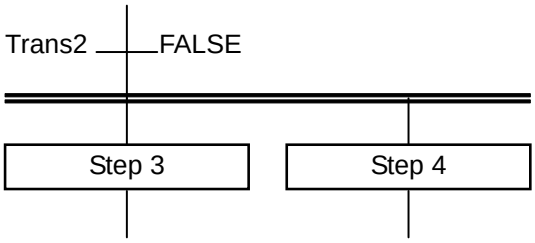
If a step before a convergence is in the active status and its transition conditions are met, the active status will be transferred provided that the step after the transition is currently in the inactive status.

Procedures:

Adding a Convergence
Right-click a transition and select ***Add Convergence***. Right-click an existing convergence and select ***Connections*** - ***Add Connection***, or right-click and select ***Connections*** - ***Add Connection to Convergence***.

2-3-6 Simultaneous Sequence Divergences

A simultaneous sequence divergence is a program control structure for SFC, in which two or more steps are connected after a single transition.
A simultaneous sequence divergence is represented by two horizontal lines.
A single step is branched into two or more steps, which are made active at the same time.



Administering Simultaneous Sequence Divergences

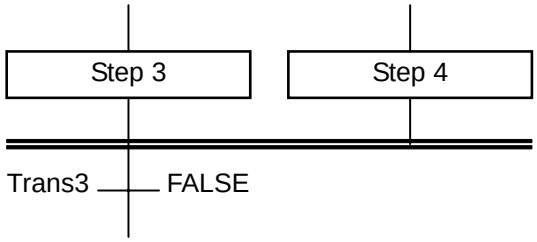
If a step before a transition is in the active status and its transition conditions are met, the active status will be transferred to all the steps after the divergence at the same time, provided they are all currently in the inactive status.
Following the transfer, all the steps immediately after the double line are simultaneously made active, and are executed in order from left to right.

Procedures:

Adding a Simultaneous sequence divergence
Right-click a transition and select ***Add Simultaneous Sequence Divergence***. To make a simultaneous sequence divergence with three or more branches, right-click an existing simultaneous sequence divergence, and select ***Add Simultaneous Divergent Step Branch*** to add a branch.

2-3-7 Simultaneous Sequence Convergences

A simultaneous sequence convergence is a program control structure for SFC, in which a single transition is connected after two or more steps.
A simultaneous sequence convergence is represented by two horizontal lines.
A simultaneous sequence convergence merges a process flow, which has been split into two or more process flow (i.e. by a simultaneous sequence divergence).



Administering Simultaneous Sequence Convergences

If all the steps before a transition are in the active status, and their transition conditions are met, the active status will be transferred from all the steps before the transition to the step after the transition at the same time, provided that the step following the transition is currently in the inactive status.

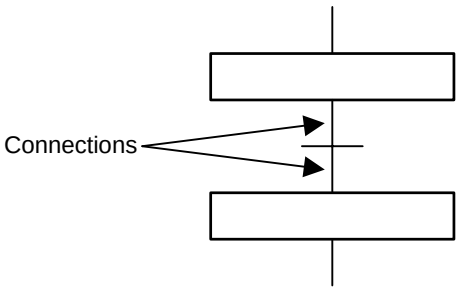
Procedures:

Adding a Simultaneous Sequence Convergence

Right-click a step and select ***Add Simultaneous Sequence Convergence***. Right-click an existing simultaneous sequence convergence and select ***Connections*** - ***Add Connection***, or right-click and select ***Connections*** - ***Add Connection to Convergence***.

2-3-8 Connections

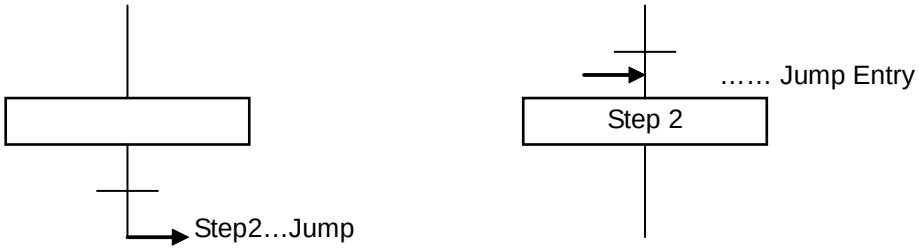
A connection is the line, which connects elements such as steps and transitions, and represents the process flow.



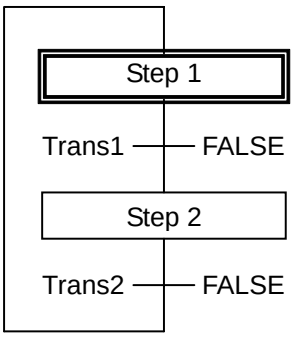
Jump (Loop)

This is a function with which to make the execution “jump” from a transition to a specified step.
A jump and a loop are functionally identical, but whereas the source and the destination are not connected for a jump, they are connected for a loop.

Jump



Loop



- With a jump, an arrow and the step number for the jump destination are described after a transition.
- A jump entry is represented by an arrow immediately before the jump destination step (after the transition).
- When the transition conditions for the transition after the jump source step are met, the active status is transferred, provided that the jump destination step is currently in the inactive status.

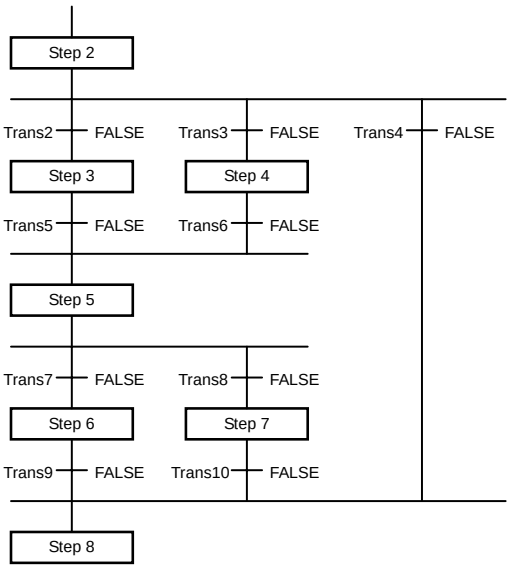
Procedures:

Adding a Jump

Right-click a transition, select ***Connections*** - ***Add Jump From Transition*** to prepare a connection, and then connect it to step, which will become the destination of the jump.

Skip

Skip is a divergence, which has a transition element but no step element.



Procedures:

Adding a Skip

Right-click a convergence, select ***Connections*** - ***Add Connection To Convergence*** to prepare a connection, and then connect it to the transition to be skipped.

2-3-9 Automatic Registration of SFC Elements as Local Variables

When a step, an action program, a transition, action with a bit specification, or an SFC element for a subchart is created, a system variable is automatically registered in the local symbol table.

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Offline Operations

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3-1 Creating an SFC Program

3-1-1 Creating a New Project

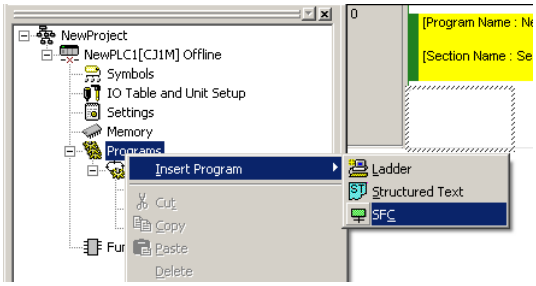
1 Start CX-Programmer and select ***New*** from the File menu.
2 From the *Device Type* list on the Change PLC dialog, select a PLC model, which supports the SFC programming function; a list of which is provided below.

PLC Model	CPU Type
CJ2H	Type: CJ2H-CPU68/67/66/65/64/68-EIP/67-EIP/66-EIP/65-EIP/64-EIP
CJ2M	Type: CJ2M-CPU11/12/13/14/15/31/32/33/34/35
CS1G-H	Type: CS1G-CPU45H/44H/43H/42H
CS1H-H	Type: CS1H-CPU67H/66H/65H/64H/63H
CJ1G-H	Type: CJ1G-CPU45H/44H/43H/42H
CJ1H-H	Type: CJ1H-CPU67H/66H/65H/67-R/66-R/65-R/64-R
CJ1M	Type: CJ1M-CPU23/22/21/13/12/11

3 Press the **Settings** button to select a CPU type.
For details on other settings, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

3-1-2 Creating (Inserting) a New SFC Program

Use the following procedure to create an SFC program for a project.
1 In the project workspace, right-click the *Programs* item, and select ***Insert Program*** - ***SFC*** from the pop-up menu.

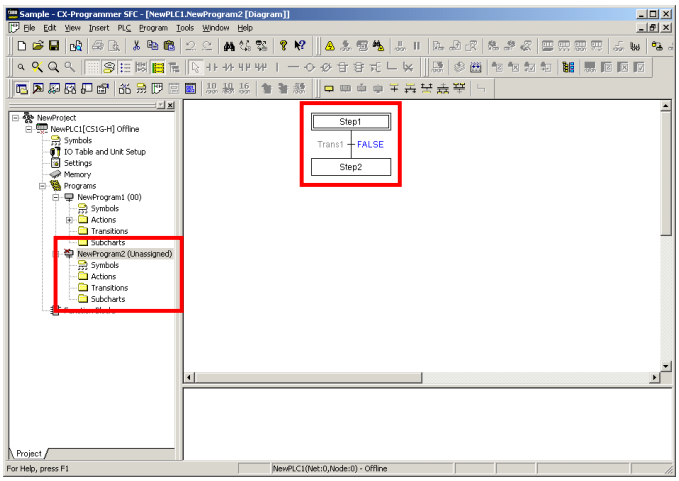


2 An SFC program is inserted into the project workspace, and the SFC editor is displayed in the right of the workspace.

Note: You can also create programs in either ladder or ST. Right-click the *Programs* item in the project workspace, and select ***Insert Program*** - ***Ladder*** or ***Insert Program*** - ***Structured Text*** from the pop-up menu.
For details on ladder programs, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).
For details on ST programs, refer to the *CX-Programmer Operation Manual – Function Blocks and Structured Text* (Cat. No. W447).

Note: SFC programs can be set as the default program of a newly created project. Setup is performed on the **PLCs** tab under ***Tools*** - ***Options***.
For details, refer to *1-3-6 Environmental Settings Unique to the SFC CX-Programming Functions*.

SFC chart editor has 3 types of SFC elements (Initial Step, Transition, and Step) registered by default.



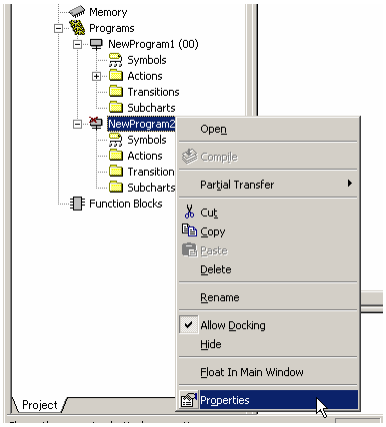
3-1-3 Allocating an SFC Program to a Task

An SFC program inserted into a project must be allocated to a “task”, which is the unit for execution.
A program that is yet to be allocated to a task will be shown in the project workspace with a check mark on its program icon.

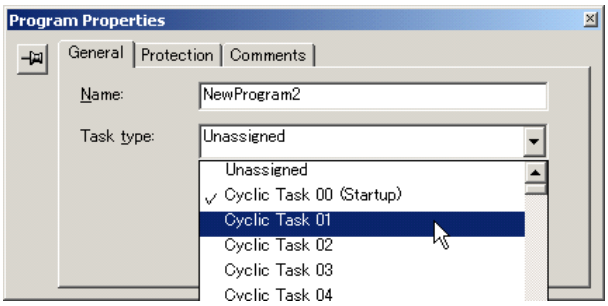
Note: The following procedure for allocating a program to a task may be postponed until program creation is completed. Be sure to allocate the program, however, before transferring it to the PLC as a user program.

Use the following procedure to allocate a program to a task.

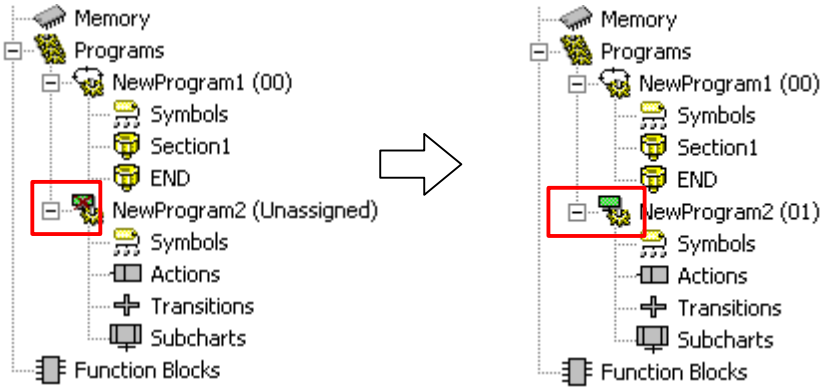
1 In the project workspace, right-click the inserted SFC program item, and then select ***Properties*** from the pop-up menu.



2 On the **General** tab of the displayed Program Properties dialog, select a task from the *Task Type* list.
To set the program name, input the program name into the *Name* text box at this point.



3 Click the close button to close the Program Properties dialog.



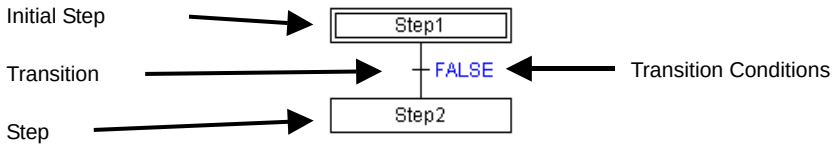
4 When the program is allocated to a task, the check mark will be removed from its SFC program item icon in the program directory. Furthermore, the task to which the program is allocated will be indicated in parenthesis, next to the program name.

3-2 Editing the SFC Chart

This section describes the process of creating an SFC chart using the SFC editor to connect various SFC elements.

3-2-1 Default Elements of an SFC Program

When a new SFC program is created in the project workspace, the following SFC elements are automatically generated in the SFC editor.



Initial Step

This is the step that becomes active upon program execution start. It is represented by a double-line frame.
It will be assigned the name, [Step 1] by default, but this can be changed.
For details, refer to *1-3-6 Environmental Settings Unique to the SFC CX-Programming Functions*.

Transition

The transition conditions (conditions for transferring from the active step to the next step) are set to the right-hand side of a transition in one of the following ways.

- Bit (Boolean variable or actual address)
- Inputting a ST expression (other than FALSE)
- Inputting a transition program name (ladder or ST)

Transition conditions are set to the ST expression “FALSE” (conditions not fulfilled) by default.

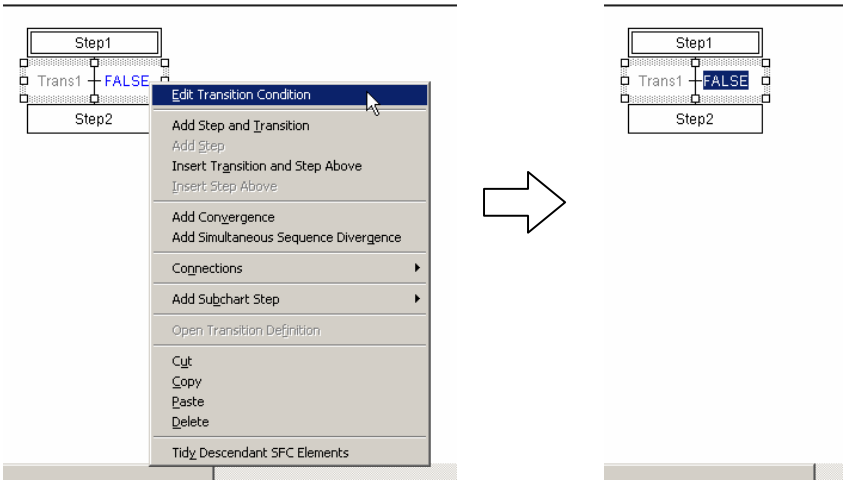
Step

A step is the box in which the processing details for a single process are stored. It is represented by a single-line frame.
It will be assigned the name, [Step 2] by default, but this can be changed.
For details, refer to *1-3-6 Environmental Settings Unique to the SFC CX-Programming Functions*.
Processes can be added as “actions” in an action block, for execution upon activation of the step. There is no limit on the number of actions that can be added.

3-2-2 Editing (Inputting) a Transition

A transition condition can be defined by direct input of a Boolean variable or by an ST expression.
Alternatively, a transition program can be utilized by specifying the name.

1 To input a transition condition, double-click the target transition, or right-click and select ***Edit Transition Condition*** from the pop-up menu.



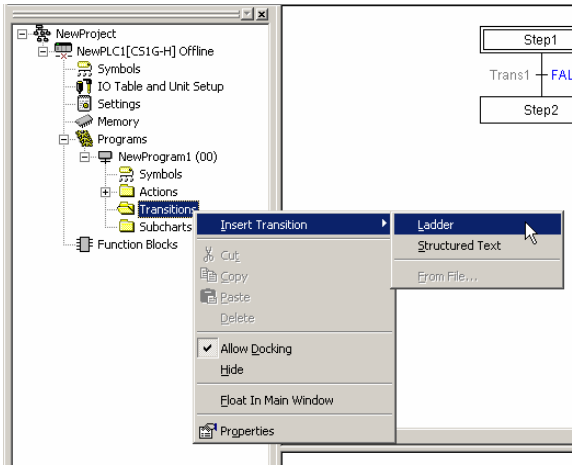
The default display (ST expression of “FALSE”) changes to the editable state.

2 Input a Boolean variable (e.g. “a”), an ST expression (e.g. “a=b”), or a transition program name.

Creating a Transition Program and Defining it as a Transition

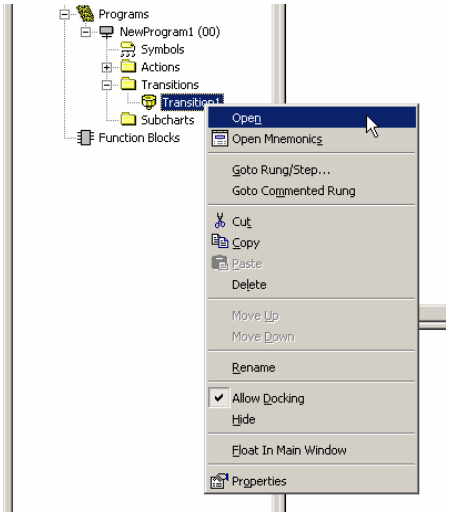
A transition program can be created in advance, for use as a transition condition.
Transition programs can be coded in either ladder or ST.

1 Right-click the *Transitions* folder in the project workspace, and select ***Insert Transition*** – ***Ladder*** or ***Structured Text*** from the pop-up menu.



A transition program (ladder or ST) will be registered under the *Transitions* folder.

2 Double-click a transition program item (ladder or ST) in the project workspace, or right-click and select ***Open*** from the pop-up menu.



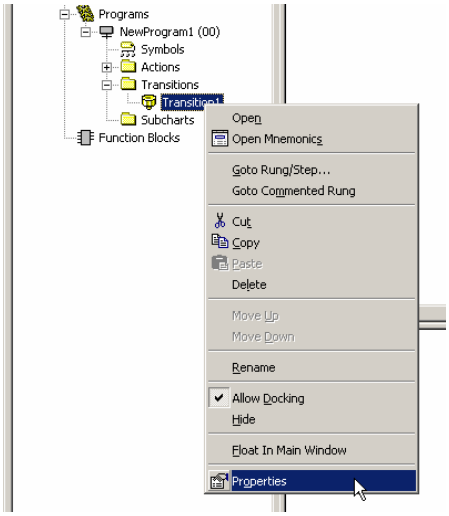
The edit window for the transition program (ladder or ST) will open, allowing you to create the program.
For details on editing in ladder or ST, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

3 Input the name of the transition program as a transition condition.

Assigning a Transition Program Name to a Transition

A transition program can be set as a transition condition by assigning its name to a transition.
Transition program names can be changed so that they are more self-explanatory.

1 Right-click the *Transitions* folder in the project workspace, and select ***Properties*** from the pop-up menu.



The Transition Properties dialog is displayed.

2 Under the **General** tab, input the transition program name into the *Name* field.
3 Click the close button to close the Transition Properties dialog.
4 Input the new transition program name as a transition condition.

3-2-3 Adding an Action to a Step (or to the Initial Step)

Right-click a step (or the initial step), select ***Add Action*** from the pop-up menu, and select one of the following.

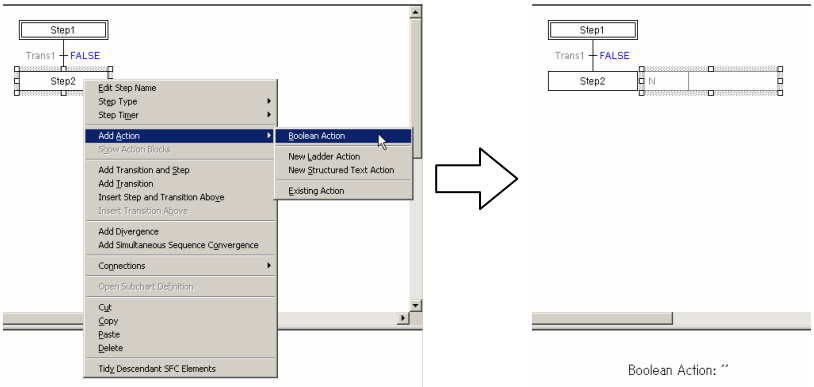
- Boolean Action (Boolean variable or actual address)
- New Ladder Action
- New Structured Text Action
- Existing Action

Adding a Boolean Variable Action Block

Action blocks can be inserted into each step of an SFC chart.
Here, a Boolean variable (bit) action block will be inserted.

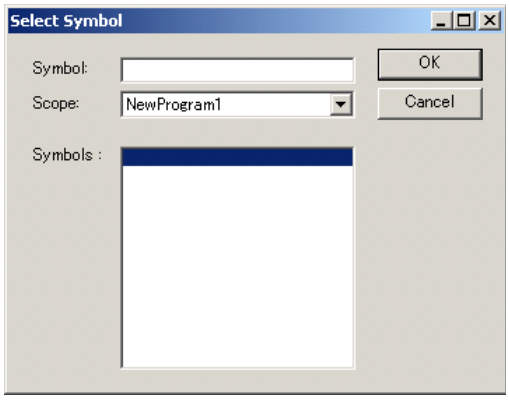
1 Select and right-click a step, and select ***Add Action*** - ***Boolean Action*** from the pop-up menu.

Note: Multiple action blocks can be inserted into a single step by repeating this procedure. If a step contains multiple action blocks, they will be executed in sequence from top to bottom.



An action block is inserted to the right of the step.

2 Clicking in the action will display a 'Browse' button "[…]". The Select Symbol dialog box (shown below) will be displayed.



3 Select a variable from the list shown, or enter a variable name in the *Symbol* field, and click ***OK***.

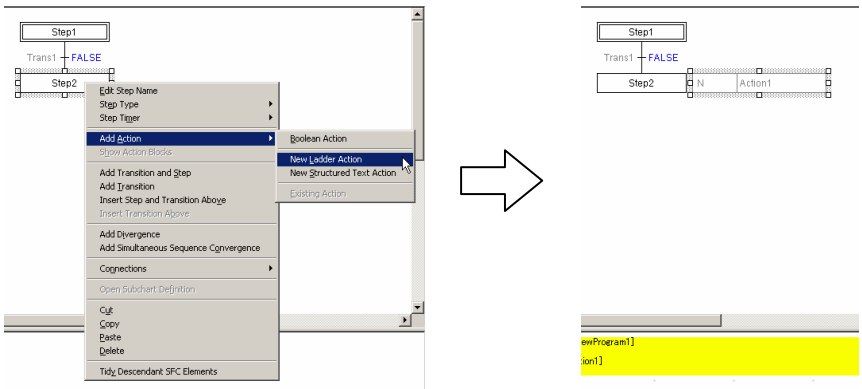
Note: The variables shown are already registered in the local symbol table. If the entered variable does not currently exist, enter the variable name in the *Name* field, and click ***OK***. A prompt to create the variable will be displayed. If 'Yes' is selected, then a variable will be added to the Local Symbol table.

Adding a Ladder Program Action Block and Editing the Ladder Program

Action blocks can be inserted into each step of an SFC chart.
You can insert a ladder program, an ST program, a Boolean variable, or an actual address as an action block. Here, a ladder program will be inserted as an action block.

1 Select and right-click a step, and select ***Add Action*** - ***New Ladder Action*** from the pop-up menu.

Note: Multiple action blocks can be inserted into a single step by repeating this procedure.



2 An action block is inserted to the right of the step.
When the action block is inserted, the program view will switch to the edit window for ladder programs. Furthermore, a ladder program item will be added to the project workspace. (An icon will indicate that the item is a ladder program.)

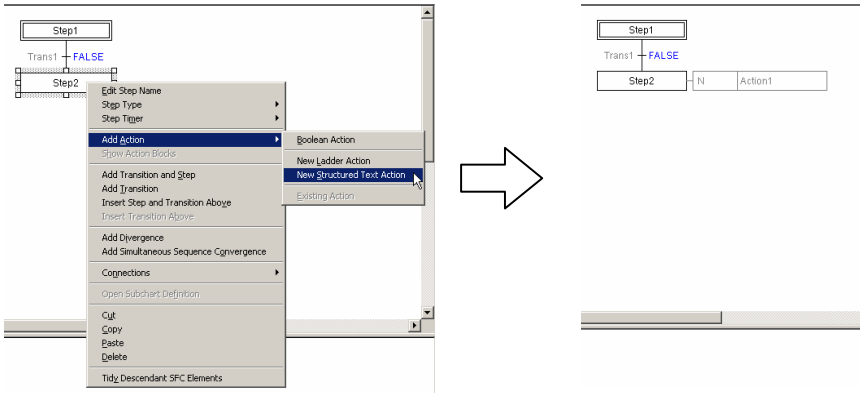
3 Use the program view to edit the ladder action program.
The ladder editing procedure is the same as for CX-Programmer. Refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

Adding an ST Program Action Block and Editing the ST Program

Action blocks can be inserted into each step of an SFC chart.
You can insert either a ladder program, an ST program, a Boolean variable, or an actual address as an action block. Here, an ST program will be inserted as an action block.

1 Select and right-click a step, and select ***Add Action*** - ***New Structured Text Action*** from the pop-up menu.

Note: Multiple action blocks can be inserted into a single step by repeating this procedure.



2 An action block is inserted to the right of the step.
When the action block is inserted, the program view will switch to the edit window for ST programs. Furthermore, an ST program item will be added to the project workspace. An icon will indicate that the item is an ST program.

3 Use the program view to edit the ST action program.
The ST editing procedure is the same as for CX-Programmer. Refer to the

CX-Programmer Operation Manual (Cat. No. W446).

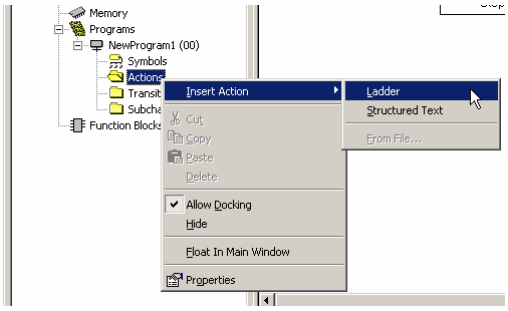
Creating an Action Program in Advance and Assigning as an Existing Program

An action program can be created in advance, and can be assigned to an SFC chart action block as an “existing action.”

Creating a New Action Program

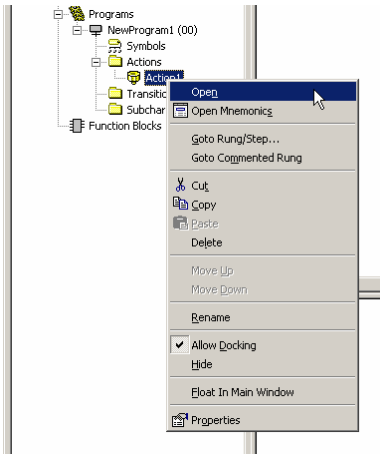
New action programs can be created in either ladder or ST.

1 Select and right-click an *Actions* folder in the project workspace, and select ***Insert Action*** - ***Ladder*** or ***Structured Text*** from the pop-up menu.



An action program (ladder or ST) will be registered under the *Actions* folder.

2 Double-click the action item (ladder or ST), or right-click and select ***Open*** from the pop-up menu.



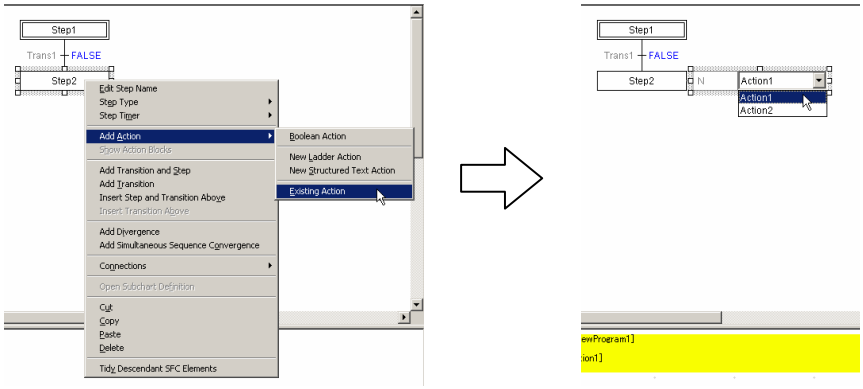
The edit window for the action program (ladder or ST) will open, allowing you to create the program.

For details on editing in ladder or ST, refer to the *CX-Programmer Operation Manual - Function Blocks and Structured Text* (Cat. No. W447).

3 Right-click a step, and select ***Add Action*** - ***Existing Action*** from the pop-up menu.

4 Right-click the added action block, and select ***Edit Action Name*** from the pop-up menu.

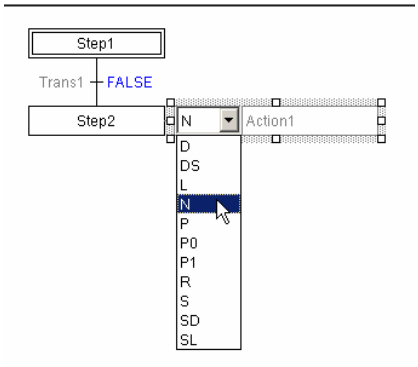
5 Select the action program from the combo list.



Setting AQs (Action Qualifiers)

This section describes how to set an AQ for an action block. One of the 11 AQs must be set for each action block. The default qualifier is 'N'.
Multiple action blocks may be inserted into a single step. If a step contains two or more action blocks, each must be configured independently.

1 Double-click the AQ of an action block, and select an AQ from the combo list.

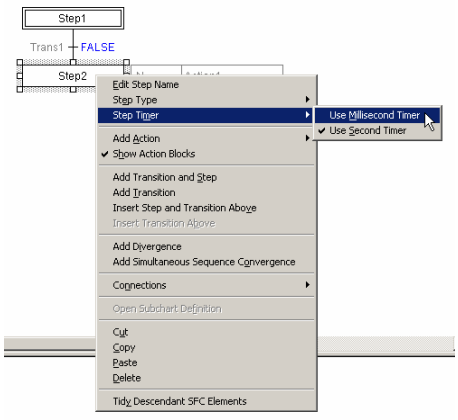


For specifications on AQ operations, refer to *2-2-3 Action Blocks*.

Setting the Timer Unit for a Step Timer

The step timer is started when a step is activated, and when "D", "L", "DS" is selected as the AQ, time control of these actions are executed according to the present value of the step timer.
The unit of a step timer can be set to seconds or 100 milliseconds.

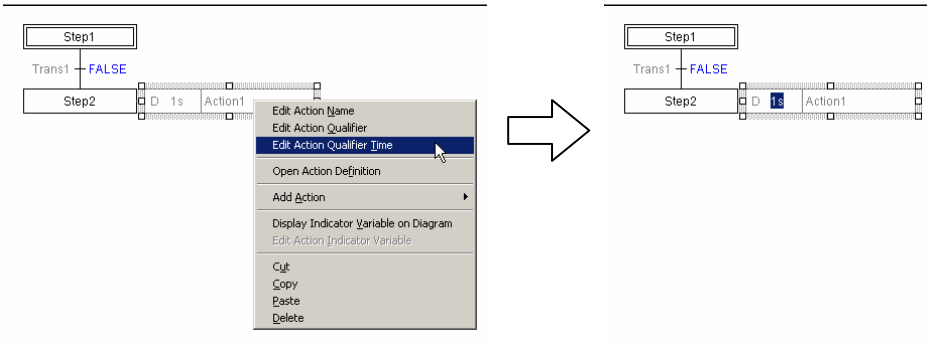
1 Right-click the step, and select ***Step Timer*** - ***Use Second Timer*** or ***Use Millisecond Timer*** from the pop-up menu.



Setting the Timer Value for an AQ (Action Qualifier)

When “D”, “L”, “DS”, “SD”, or “SL” is selected as the AQ, the timer value must be set. Actions are controlled according to the AQ when the step timer reaches the specified timer value.

1 Right-click an action block, and select ***Edit Action Qualifier Time*** from the pop-up menu.

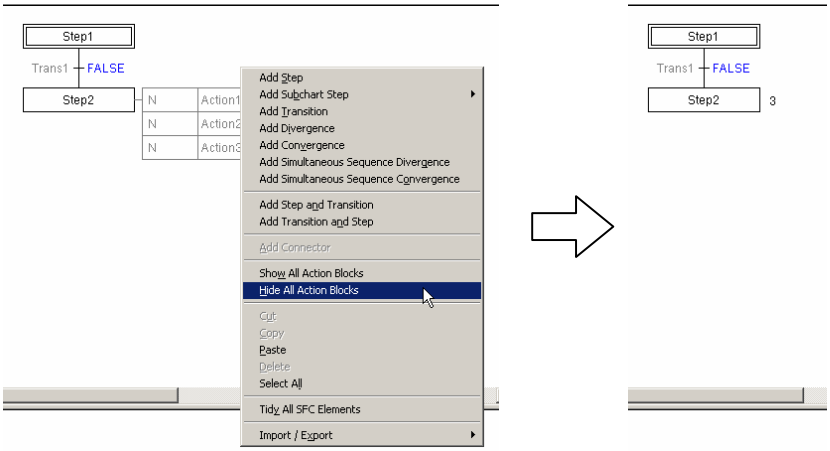


2 Input the timer value.
0 – 65535 for a one second timer, or 0 – 6553.5 for a millisecond timer.

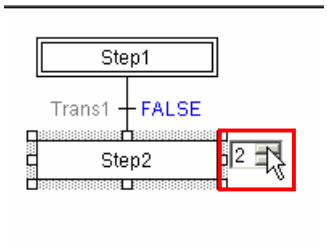
Note: The unit for the AQ timer value is determined by the step timer setting. Right-click the step, and select ***Step Timer*** - ***Use Second Timer*** or ***Use Millisecond Timer*** from the pop-up menu.

Hiding the Action Blocks

Action blocks may be shown/hidden on the SFC chart.
While the action blocks are displayed, right-click the background of the SFC editor and select ***Hide All Action Blocks*** from the pop-up menu.



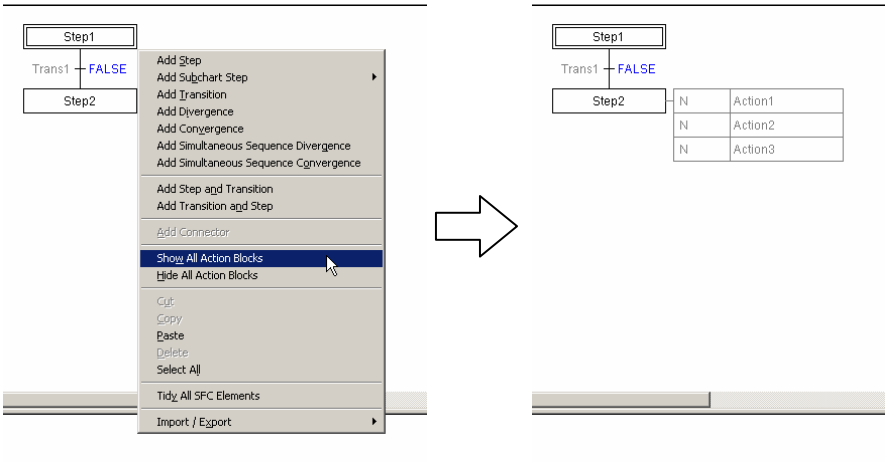
All action blocks on the SFC chart will be hidden. The number of action block included in a step will be displayed to the right of each step.



Alternatively, clicking an action on the SFC chart will display the action in the split window (program view), as will clicking the number for a hidden action block, which in turn will display a spin box. Change the number to switch the required action program displayed in the program view.

Showing the Action Blocks

Action blocks may be shown/hidden on the SFC chart.
While the action blocks are hidden, right-click the background of the SFC editor and select ***Show All Action Blocks*** from the pop-up menu.



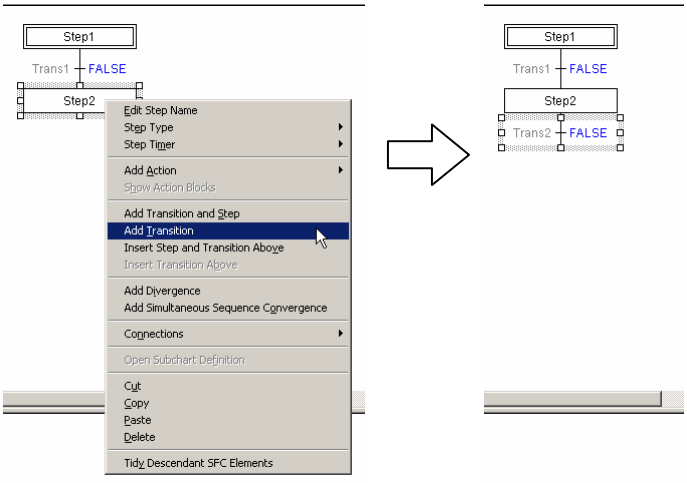
Note: The actions associated with an individual step may be shown/hidden.
While the action blocks are displayed, right click the required step, and de-select ***Show Action Blocks*** from the pop-up menu.
To display action blocks for an individual step when hidden, right-click the required step, and select ***Show Action Blocks*** from the pop-up menu.

When more than one action is registered, the actions are executed from top down in the order they are arrange in the action program tree in the workspace.

3-2-4 Adding a Transition

A transition can be added after a step (or subchart step).

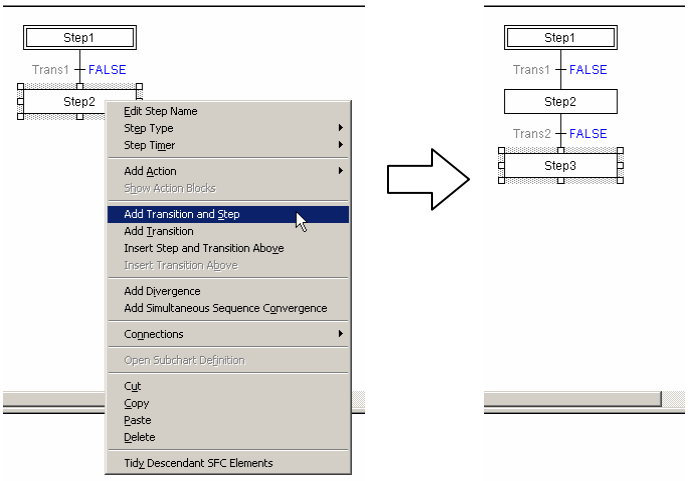
1 Right-click a step (or subchart step), and select ***Add Transition*** from the pop-up menu.



Adding a Transition and a Step

A transition and a step can be simultaneously added after a step (or subchart step).

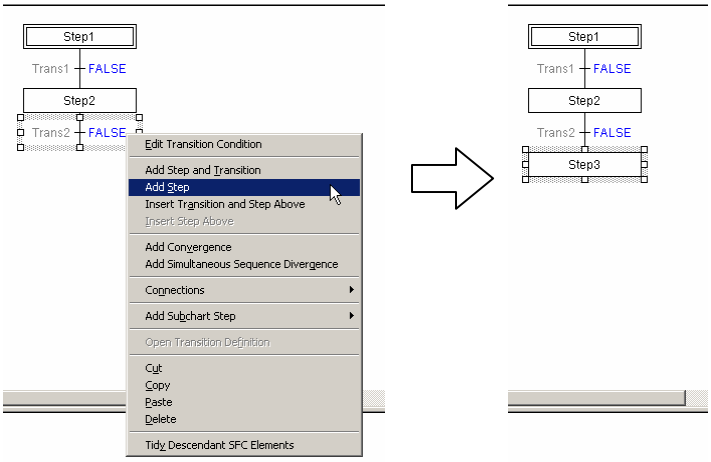
1 Right-click a step (or subchart step), and select ***Add Transition and Step*** from the pop-up menu.



3-2-5 Adding a Step

A step can be added after a transition.

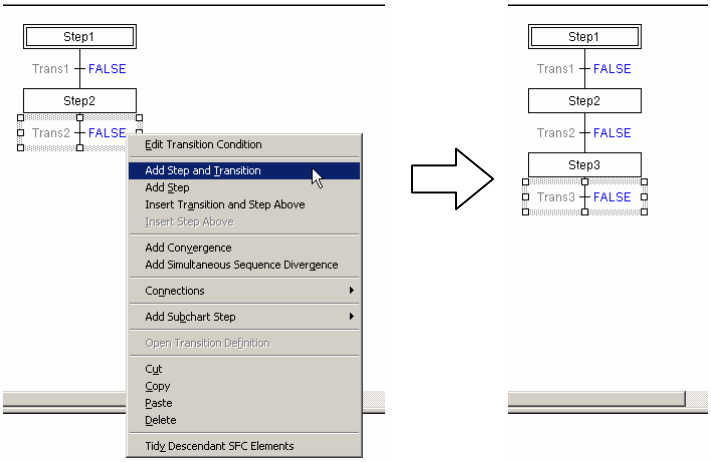
1 Right-click a transition, and select ***Add Step*** from the pop-up menu.



Adding a Step and a Transition

A step and a transition can be simultaneously added after a transition.

1 Right-click a transition, and select ***Add Step and Transition*** from the pop-up menu.

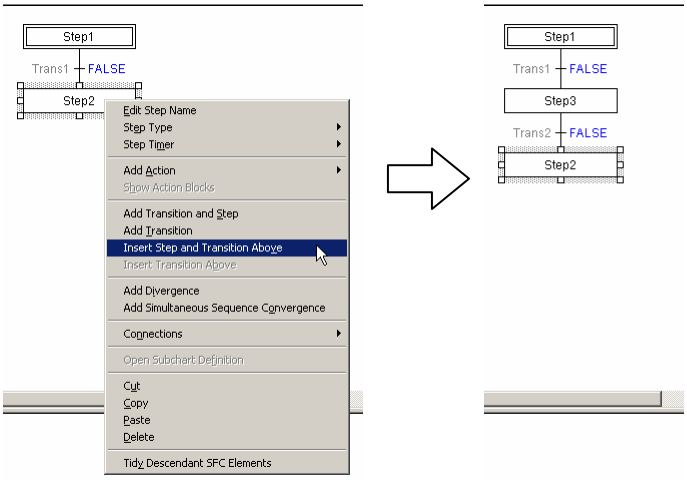


3-2-6 Inserting Immediately Before a Step or Transition

Inserting a Step and a Transition Before a Step

A step and a transition can be inserted before a step (or subchart step).

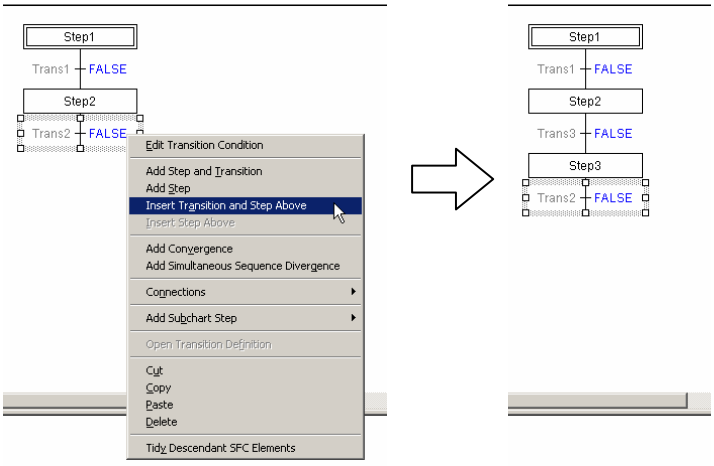
1 Right-click a step (or subchart step), and select ***Insert Step and Transition Above*** from the pop-up menu.



Inserting a Transition and a Step Before a Step

A transition and a step can be inserted before a transition.

1 Right-click a transition, and select ***Insert Transition and Step Above*** from the pop-up menu.



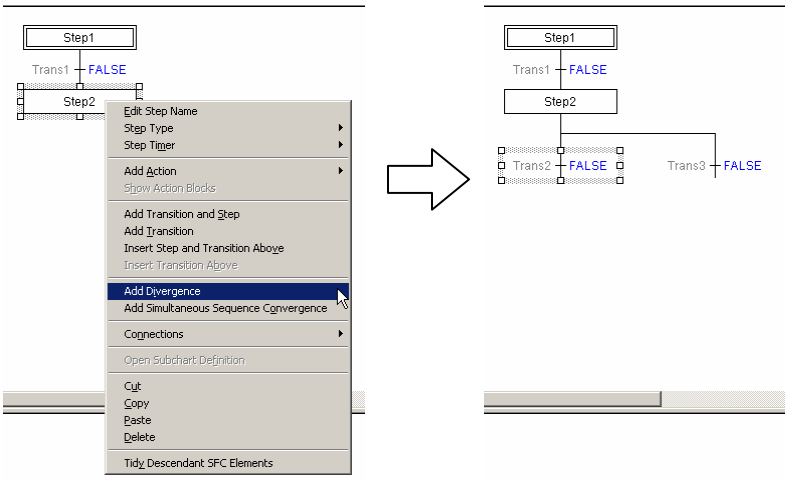
3-2-7 Creating a Divergence/Convergence

Creating a Divergence

Adding 2 Transitions

A divergence can be added after a step (or subchart step).

1 Right-click a step (or subchart step), and select ***Add Divergence*** from the pop-up menu.



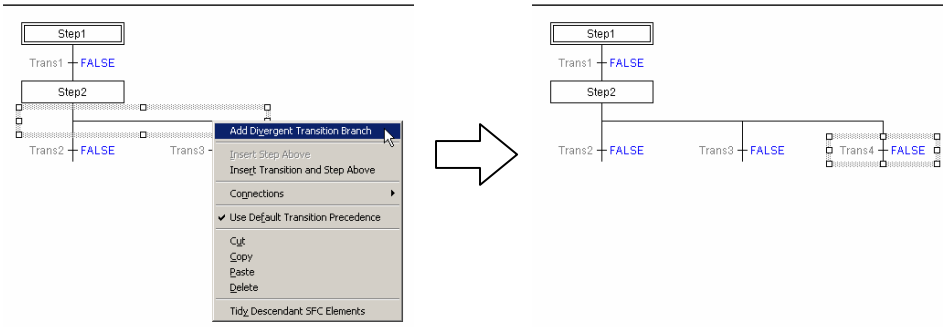
A divergence and 2 subsequent transitions will be added.

When using a divergence, add SFC elements so that each branch ends with a transition, enabling a convergence.

Adding More Transitions

Branches can be added to a divergence.

1 Right-click an existing divergence, and select ***Add Divergent Transition Branch*** from the pop-up menu.

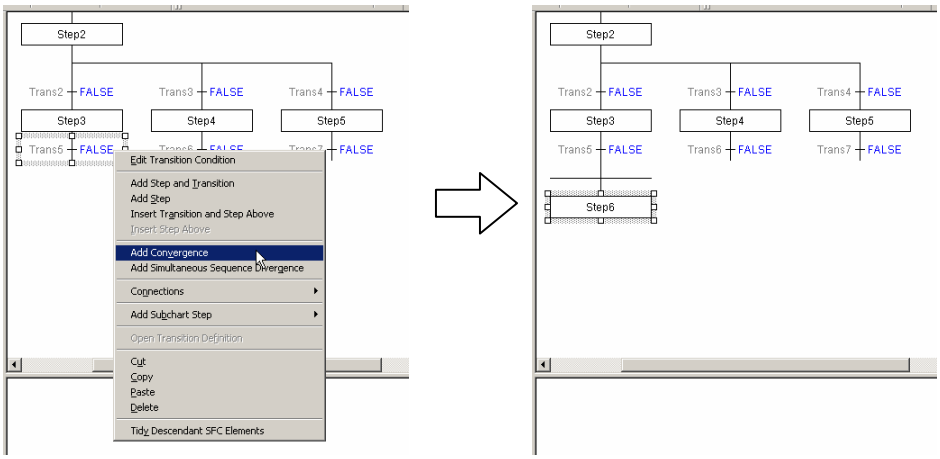


A transition is added to the divergence.

When using a divergence, add SFC elements so that each branch ends with a transition, enabling a convergence.

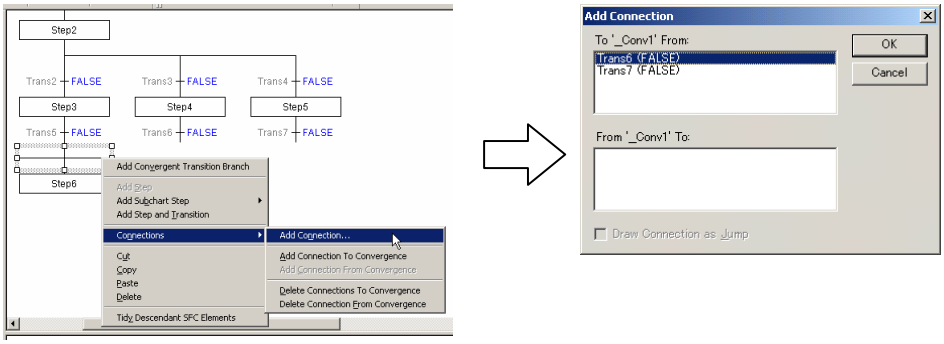
Creating a Conditional Join

Add a convergence to merge conditionally branched SFC chart process flows.
In order to add a convergence, each conditionally branched process flow must have a transition as its terminating element.
Right-click one of the conditionally branched transitions, and select ***Add Convergence*** from the pop-up menu.



A convergence and a subsequent step will be added.

2 Right-click the created convergence, and select ***Connections - Add Connection*** from the pop-up menu.



The Add Connection dialog will be displayed.

3 Confirm that the transitions to be joined are selected in the Add Connection dialog, and click ***OK***.

The selected transitions will be joined to the convergence.

Note 1: You can also right-click the convergence, select ***Connections*** - ***Add Connection to Convergence*** from the pop-up menu, and drag the lead line to the target transition to connect transitions to a convergence.

2: Right-click the line next to a conditional branch and select ***Use Default Transition Precedence*** to numerically display the execution order starting from 1. Then double-click the numbers to change the execution order as desired.

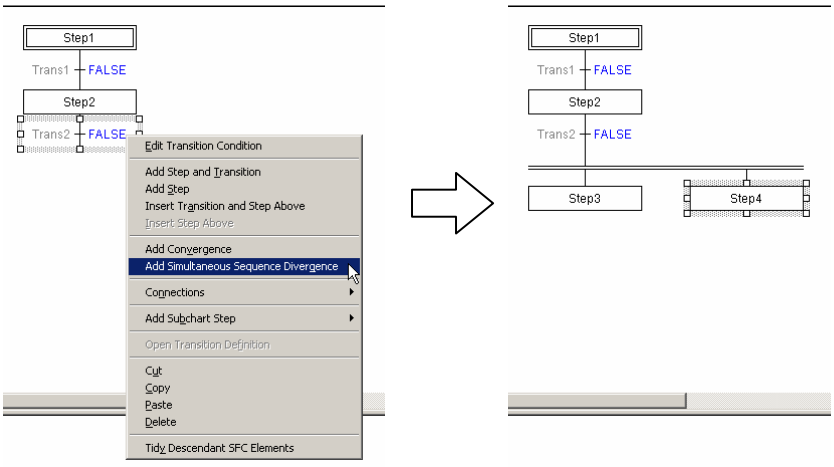
3-2-8 Creating a Simultaneous Sequence Divergence/Convergence

Creating a Simultaneous Sequence Divergence

Adding 2 Steps

A simultaneous sequence divergence can be added after a transition.

1 Right-click a transition, and select ***Add Simultaneous Sequence Divergence*** from the pop-up menu.



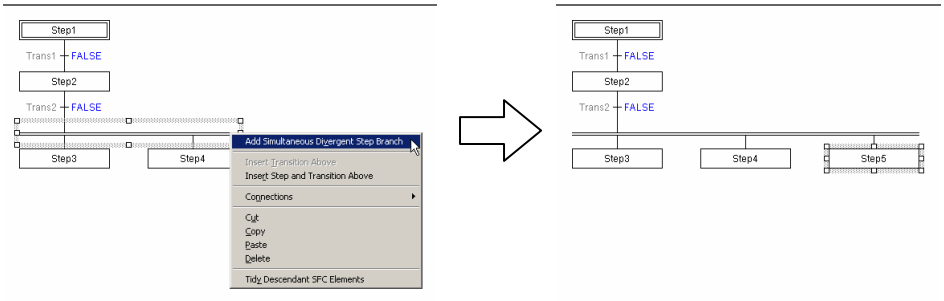
A simultaneous sequence divergence and 2 subsequent steps will be added.

When using a simultaneous sequence divergence, add SFC elements so that each branch ends with a step (or subchart step), enabling a simultaneous sequence convergence.

Adding More Steps

Branches can be added to a simultaneous sequence divergence.

1 Right-click an existing simultaneous sequence divergence, and select ***Add Simultaneous Divergent Step Branch*** from the pop-up menu.

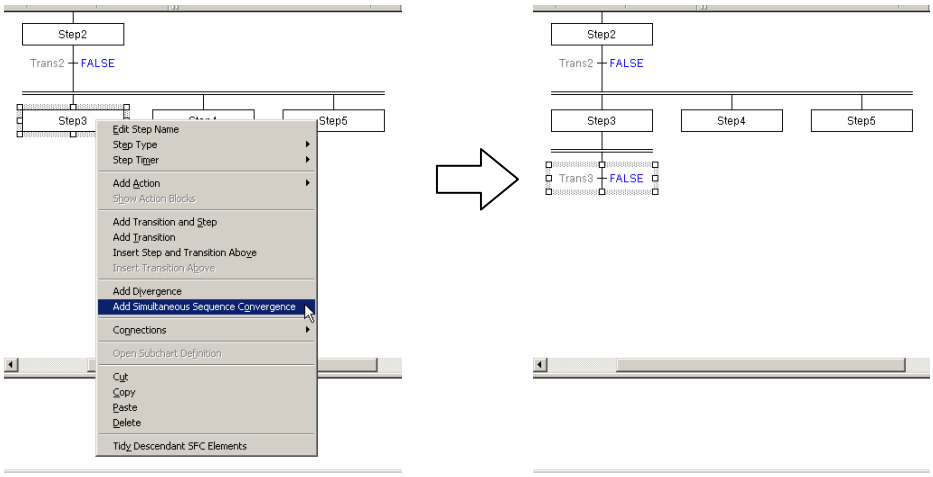


A step is added to the simultaneous sequence divergence.

Creating a Simultaneous Sequence Convergence

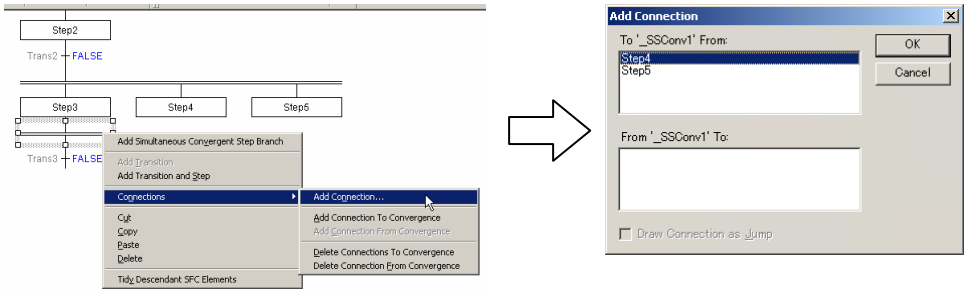
Add a simultaneous sequence convergence to merge parallel-branched SFC chart process flows.
In order to add a simultaneous sequence convergence, each parallel-branched process flow must have a step (or subchart step) as its terminating element.

1 Right-click one of the branched steps (or subchart steps), and select ***Add Simultaneous Sequence Convergence*** from the pop-up menu.



A simultaneous sequence convergence and a subsequent transition will be added.

2 Right-click the simultaneous sequence convergence, and select ***Connections*** - ***Add Connection*** from the pop-up menu.



The Add Connection dialog will be displayed.

3 Confirm that the transitions to be joined are selected in the Add Connection dialog, and click ***OK***.

The selected steps (or subchart steps) will be joined to the simultaneous sequence convergence.

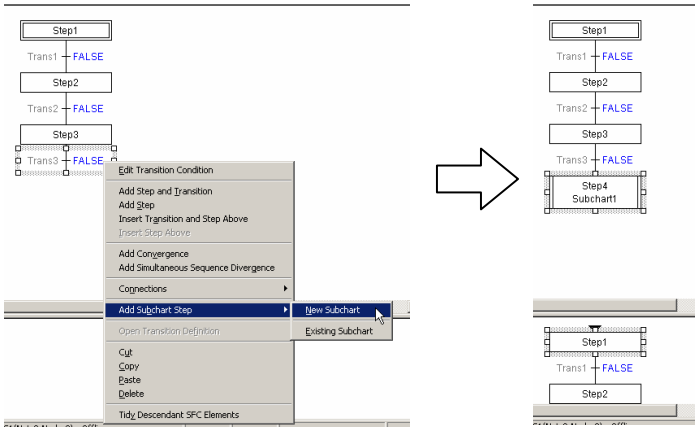
Note: You can also right-click the simultaneous sequence convergence, select ***Connections*** - ***Add Connection to Convergence*** from the pop-up menu, and drag the lead line to the target step to connect steps to a simultaneous sequence convergence.

3-2-9 Adding a Subchart

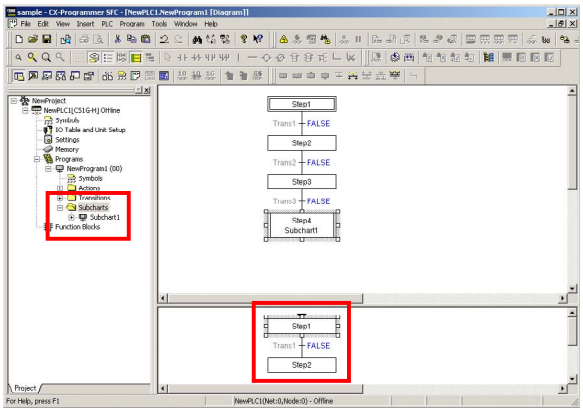
Adding a Subchart Step and Creating a New Subchart Program

A subchart step can be added after a transition. The subchart program can be created later.

1 Right-click a transition, and select ***Add Subchart Step*** - ***New Subchart*** from the pop-up menu.



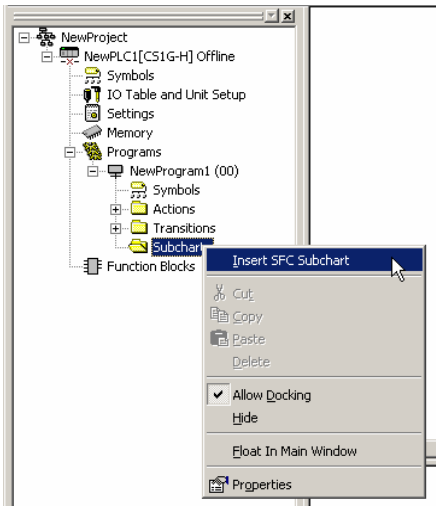
When the new subchart step is added, the default SFC subchart will be displayed in the program view. An SFC subchart item will be added to the *Subcharts* folder in the project workspace.



2 Edit the subchart.
The default subchart contains an entry step, a transition, and a step.
Edit the subchart by adding and connecting SFC elements, just as with an SFC chart.
The first SFC element must be the entry step, and the last must be the return step

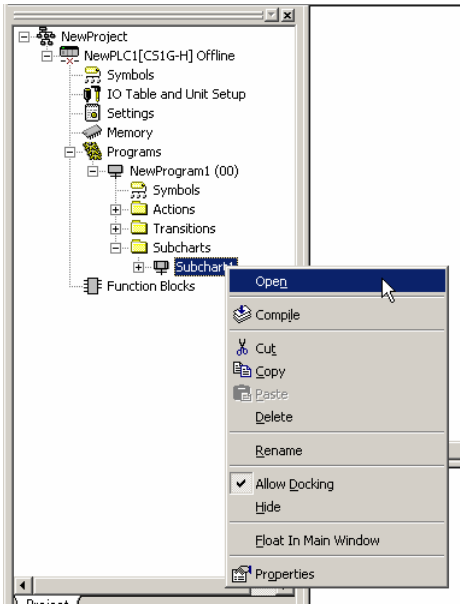
Creating a New Subchart Program and Adding an Existing Subchart Step

A subchart program can be created in advance, and used as an “existing subchart” in adding a subchart step to an SFC chart.
Right-click a *Subcharts* folder in the project workspace, and select ***Insert SFC Subchart*** from the pop-up menu.

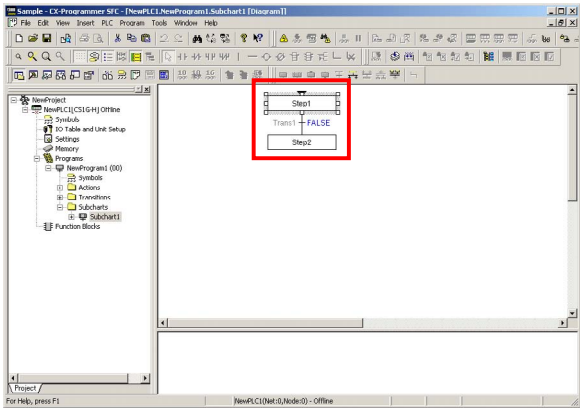


A subchart program will be registered under the *Subcharts* folder.

3 Double-click the registered subchart program, or right-click and select ***Open*** from the pop-up menu.

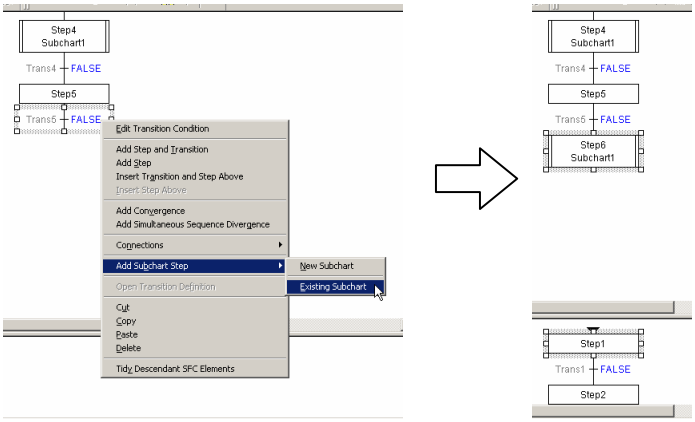


The subchart edit window will be displayed. Edit the subchart.



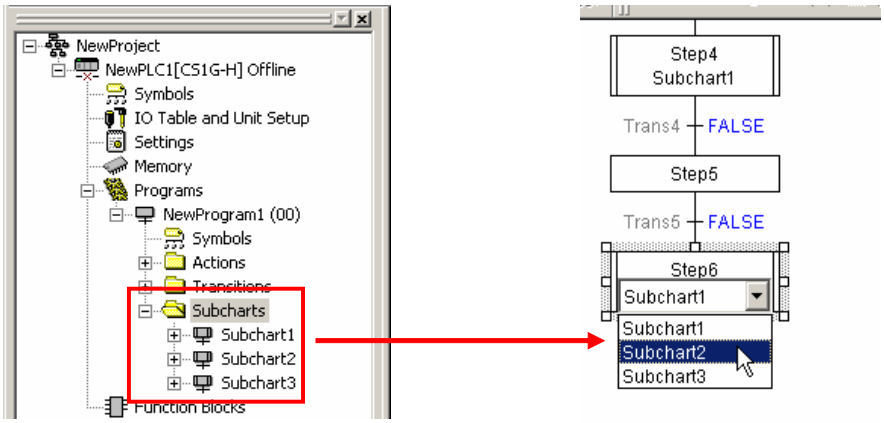
4 Double-click an SFC program in the project workspace, or right-click and select ***Open*** from the pop-up menu.

5 Right-click a transition, and select ***Add Subchart Step*** - ***Existing Subchart*** from the pop-up menu.



6 Double-click the subchart step and select the subchart program from the combo list.

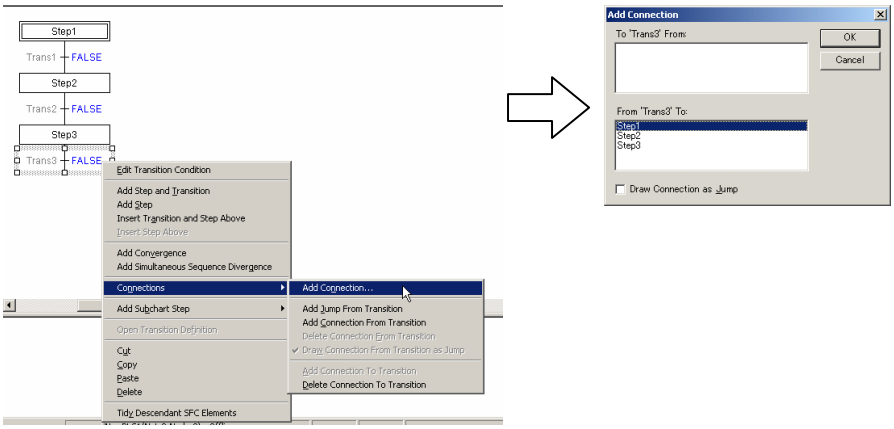
Select from subchart programs that have been registered in the project workspace as *Subcharts* folder.



3-2-10 Connecting to the Initial Step with a Jump (or Loop)

The bottom transition of an SFC chart can be connected to any other step. Right-click the bottom transition, and select ***Connections - Add Connection*** from the pop-up menu.

Note: You can also right-click a transition, select ***Connections*** - ***Add Jump*** from the pop-up menu, and drag the connection to the jump destination step to establish a connection.

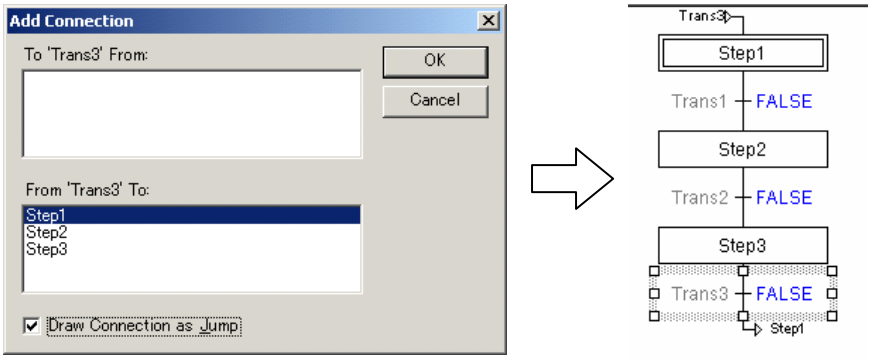


The Add Connection dialog will be displayed.

7 On the Add Connection dialog, select the destination step element.

8 Check the ***Draw Connection as Jump*** checkbox and click ***OK***.

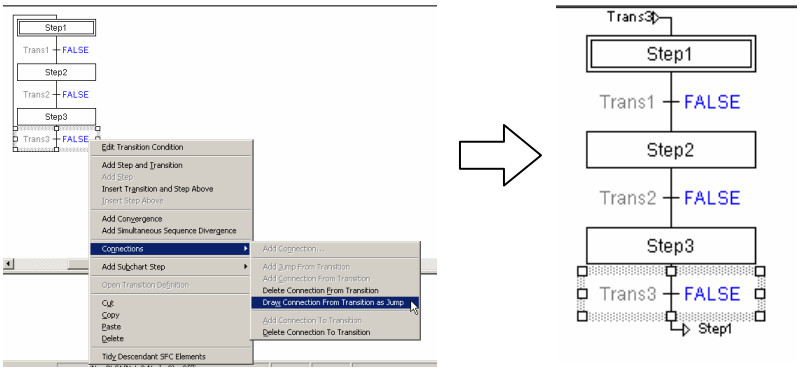
Note: For a loop connection, remove the check from ***Draw Connection as Jump*** checkbox.



Changing a Loop to a Jump

A loop can be changed to a jump.

1 Right-click a loop transition, and select ***Connections*** - ***Draw Connection From Transition as Jump*** from the pop-up menu.



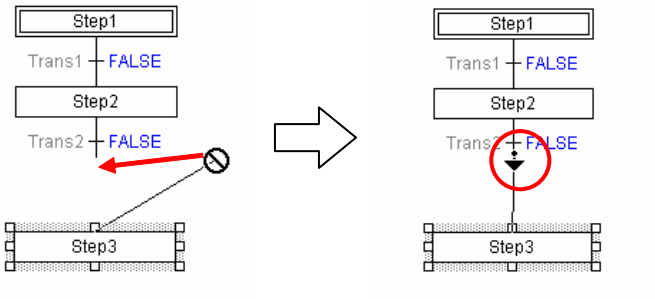
3-2-11 Editing Independent (Isolated) SFC Elements

Independent SFC elements can be inserted into the SFC editor, and can later be connected to create an SFC chart.

1 With no SFC element selected on the SFC editor, right-click the background of the SFC editor, and select an element to insert from the pop-up menu.
2 Drag-and-drop the SFC elements, and position them in the order they are to be connected.
3 Use connections to connect the SFC elements.

Connecting SFC Elements by Mouse Operation

Independent SFC elements in the SFC editor can be connected.
Draw out a connection from a selected SFC element, then, using the mouse, select the destination SFC element.
If the destination SFC element can be connected, the mouse pointer will change to a connection cursor. Click to establish the connection.



Connecting the Output of an Isolated Transition as the Input for a Step

A connection can be made from an isolated transition to a step.

1 Right-click a step, and select Connections **- Add Connection To Step** from the pop-up menu.
2 Put the mouse pointer over the output-side of the transition to be connected and click.

Connecting the Output of a Step as the Input for an Isolated Transition

A connection can be made from a step to an isolated transition.

1 Right-click a step, and select ***Connections - Add Connection From Step*** from the pop-up menu.
2 Put the mouse pointer over the input-side of the transition to be connected and click.

Connecting the Output of an Isolated Step as the Input for a Transition

A connection can be made from an isolated step to a transition.
The connection is made between the input-side of the transition and the output-side of the step.

1 Right-click a transition, and select Connections **- Add Connection From Step** from the pop-up menu.
2 Put the mouse pointer over the output-side of the step to be connected and click.

Connecting the Output of a Transition as the Input for an Isolated Step

A connection can be made from a transition to an isolated step.

1 Right-click a transition, and select Connections **- Add Connection To Step** from the pop-up menu.
2 Put the mouse pointer over the input-side of the step to be connected and click.

Connecting the Output of an Isolated Step as the Input for a Divergence; or, Connecting the Output of an Isolated Transition as the Input for a Simultaneous Sequence Divergence

A connection can be made from an isolated step to a divergence, or from an isolated transition to a simultaneous sequence divergence.

1 Right-click a divergence or on a simultaneous sequence divergence, and select Connections **- Add Connection To Divergence** from the pop-up menu.
2 For a divergence, put the mouse pointer over the output-side of the step to be connected and click. For a simultaneous sequence divergence, put the mouse pointer over the output-side of the transition to be connected and click.

Connecting the Output of a Divergence as the Input for an Isolated Transition; or, Connecting the Output of a Simultaneous Sequence Divergence as the Input for an Isolated Step

A connection can be made from an isolated transition to a divergence, or from an isolated step to a simultaneous sequence divergence.

1 Right-click a divergence or on a simultaneous sequence divergence, and select Connections **- Add Connection From Divergence** from the pop-up menu.
2 For a divergence, put the mouse pointer over the input-side of the transition to be connected and click. For a simultaneous sequence divergence, put the mouse pointer over the input-side of the step to be connected and click.

Connecting the Output of an Isolated Transition as an Input for a Convergence; or, Connecting the Output of an Isolated Step as an Input for a Simultaneous Sequence Convergence

A connection can be made from an isolated transition to a convergence, or from an isolated step to a simultaneous sequence convergence.

1 Right-click a convergence or on a simultaneous sequence convergence, and select Connections **- Add Connection To Convergence** from the pop-up menu.
2 For a convergence, put the mouse pointer over the output-side of the transition to be connected and click. For a simultaneous sequence convergence, put the mouse pointer over the output-side of the step to be connected and click.

Connecting the Output of a Convergence as the Input for an Isolated Step; or, Connecting the Output of a Simultaneous Sequence Convergence as the Input for an Isolated Transition

A connection can be made from an isolated step to a convergence, or from an isolated transition to a simultaneous sequence convergence.

1 Right-click a convergence or on a simultaneous sequence convergence, and select Connections **- Add Connection From Convergence** from the pop-up menu.
2 For a convergence, put the mouse pointer over the input-side of the step to be connected and click. For a simultaneous sequence convergence, put the mouse pointer over the input-side of the transition to be connected and click.

3-2-12 Tidying an SFC Chart

SFC elements can be tidied in the SFC editor.

Note: When a complicated SFC chart cannot be tidied as intended, recover the chart from unintentional modifications, using ***Edit*** - ***Undo***, and then adjust the chart manually.

Tidying an SFC Chart

Right-click the background of the SFC editor, and select ***Tidy All SFC Elements*** from the pop-up menu.
All elements in the SFC chart will be tidied.

Tidying Selected Elements in an SFC Chart

Right-click an SFC element in an SFC chart, and select ***Tidy Descendant SFC Elements*** from the pop-up menu.
Other SFC elements below the selected SFC element will be tidied.

3-2-13 Changing the Step Type

Changing a Normal Step to the Initial Step

Right-click the step to be changed into the initial step, and select ***Step Type*** - ***Initial*** from the pop-up menu.

Changing the Initial Step to a Normal Step

Right-click the initial step to be changed into the normal step, and select ***Step Type*** - ***Normal*** from the pop-up menu.

Changing a Normal Step to the Entry Step

Right-click a step in a subchart to be changed, and select ***Step Type*** - ***Entry*** from the pop-up menu.

Changing a Normal Step to a Return Step

Right-click a step in a subchart to be changed, and select ***Step Type*** - ***Return*** from the pop-up menu.

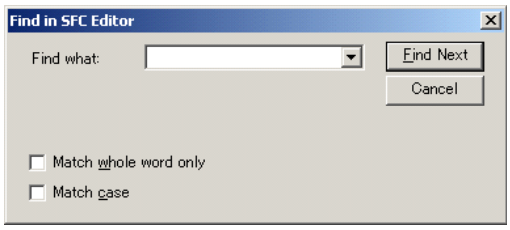
3-3 Searching and Replacing within an SFC Chart

3-3-1 Searching within an SFC Chart

The “Find” function can be used to search for text strings within an SFC chart.
If the text string is found, the SFC element containing the text string will be selected and displayed.
The following text strings can be searched.

- Step name
- Transition name
- Action program name for the action block
- Boolean symbol name for the action block
- Subchart name
- Symbol name for the transition condition
- ST expression for the transition condition
- Program name for the transition condition

1 Select Find from the Edit menu.
The Find in SFC Editor dialog will be displayed.



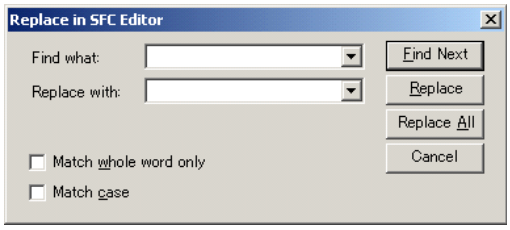
2 Input the search text into the *Find what* combo box.
Check the ***Match whole word only*** checkbox and/or mark the ***Match case*** search option as necessary.
3 Click ***Find Next***.
An SFC element containing the search text will be selected and displayed.

3-3-2 Substituting within an SFC Chart

The “Find” function can also be used to replace text strings within an SFC chart.
The following text strings can be searched.

- Step name
- Transition name
- Symbol name for the transition condition
- ST expression for the transition condition
- Program name for the transition condition
- Boolean variable name for the action block

1 Select ***Replace*** from the ***Edit*** menu.
The Replace in SFC Editor dialog will be displayed.



2 Input the search text into the *Find what* combo box, and input the replacement text into the *Replace with* combo box.
Check the ***Match whole word only*** checkbox and/or mark the ***Match case*** search

option as necessary.

3 Click ***Find Next***, then click ***Replace*** after confirming the text to be replaced. To replace all instances, click ***Replace All***.

3-3-3 Cross-Reference Report

A list of addresses used by the program can be displayed.
You can also confirm which address corresponds to which SFC element of the SFC chart.

Note: For details on cross-reference reporting function, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

1 Select ***Cross-Reference Report*** from the View menu.
The Cross-Reference Report window will be displayed.
2 Using the *Report type* combo box and *Memory Area* combo box, set the requirements for the report
3 Click Generate.

3-3-4 Address Reference Tool

The Address Reference Tool can display SFC elements and variables, which are using the same address as the selected SFC element or same variable of an SFC chart.

Note: For details on the address reference tool, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

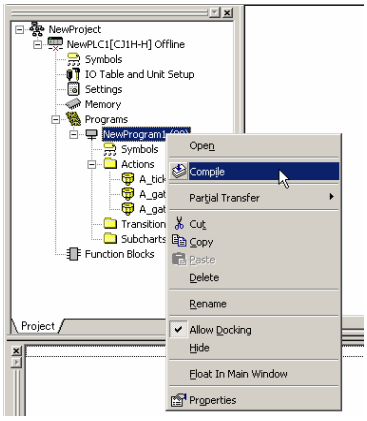
1 Select Windows - Address Reference Tool from the View menu.
The Address Reference Tool window will be displayed.
2 Select an SFC element or a variable from an SFC chart.
The selected item address will be displayed in the Address field of the Address Reference Tool window.
3 Click ***Find***.

3-4 Offline Program Check

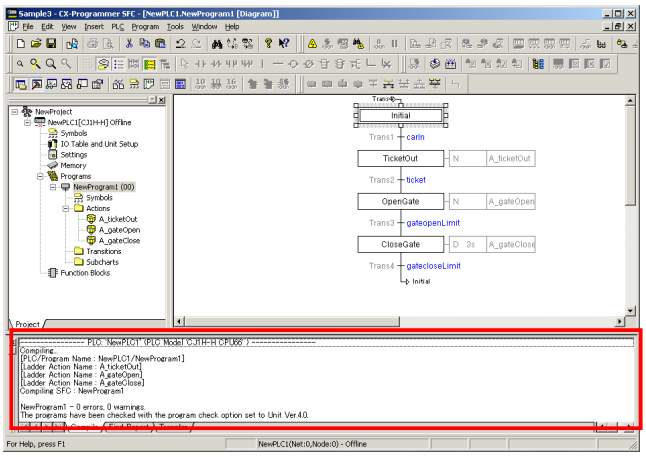
3-4-1 SFC Program Check

A program check can be performed on an SFC program.

1 Right-click an SFC program in the project workspace, and select ***Compile*** from the pop-up menu.



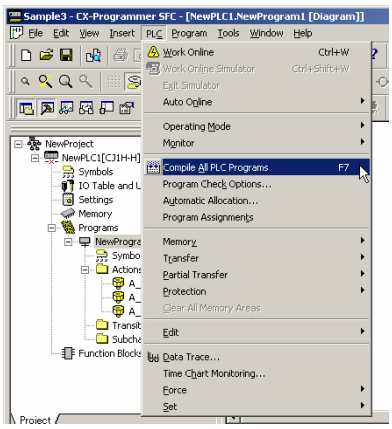
The check results for the program will be displayed on the **Compile** tab of the output window.



3-4-2 Checking All Programs

All programs, including ladder programs and ST programs for SFC programs and action programs, can be checked at the same time.

1 Select ***Compile All PLC Programs*** from the PLC menu.



The check results for the program will be displayed on the **Compile** tab of the output window.

3-5 Miscellaneous

3-5-1 Array Variables

Array variables can be used with CX-Programmer.
Array variables can handle a wide selection of data elements of the same data type.
Individual values in an array variable are specified using an indexed variable name.

Example: Variable Name [Index]

The index of an array variable indicates the position of the data element within the array.

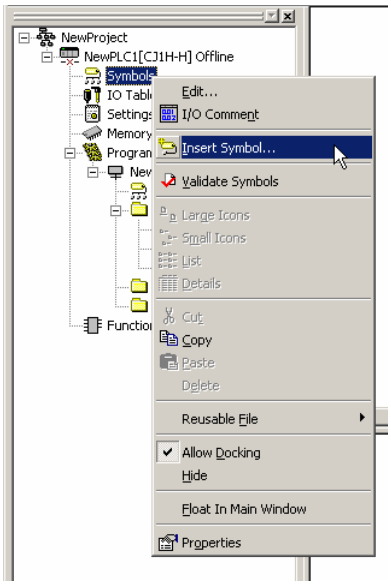
Example: bflag[5] (Numeric Value)
Example: bflag[a] (Variable)
Example: bflag[a+b] (Variable and Arithmetic Operators)

For SFC programs, ladder programs, action programs within SFC programs, and ladder programs within transition programs, the index must be a numeric value. Variables cannot be used as the index.
For ST programs, the index can be defined by both numeric value and variables.
For CJ2-series CPU Units, the index can be defined by both numeric value and variables for ladder programs.

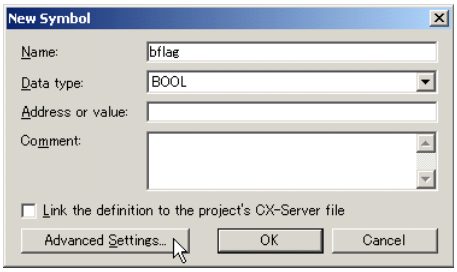
Note: For details on array variables, refer to the *CX-Programmer Operation Manual* (Cat. No. W446) and the *CX-Programmer Operation Manual – Function Blocks and Structured Text* (Cat. No. W447).

Inserting an Array Variable

1 In the project workspace, select and right-click *Symbols* folder, and select ***Insert Symbol*** from the pop-up menu.



2 Specify the variable in the displayed New Symbol dialog, and click ***Advanced Settings***.



3 On the displayed Advanced Settings dialog, check the ***Array Symbol*** checkbox, input the size of the array, and click ***OK***.

4 Click ***OK*** on the displayed New Symbol dialog. The array variable is inserted into the *Symbols* folder.

3-5-2 Printing

The display in SFC View and programs and subcharts in an SFC chart can be printed. Comments can be included. Refer to the *CX-Programmer Operation Manual* (Cat. No. W446) for details.

SECTION 4
Online Operations

4-1 Connecting the PLC 94
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4-1-2 Working Offline 94
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4-5-3 Monitoring Action/Transition Programs 100

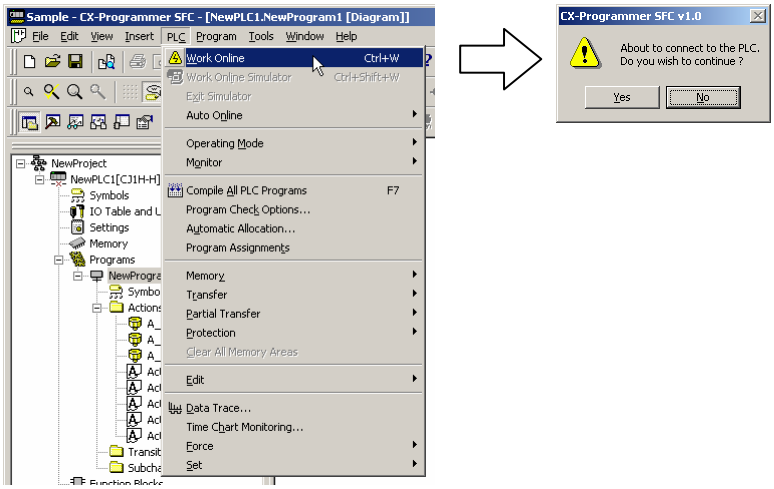
4-1 Connecting the PLC

This section describes how to connect a PLC to a computer.

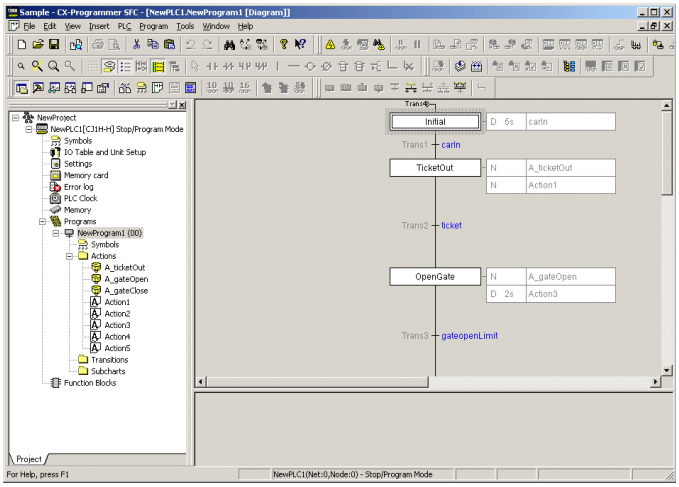
4-1-1 Working Online

While displaying the SFC editor, switch to the online mode.

1 Select ***Work Online*** from the PLC menu.
A confirmation message is displayed.



2 Click ***YES***.
You will be switched to the online state, and the online SFC editor is displayed.
(The SFC editor is displayed in gray to indicate that you are working online.)



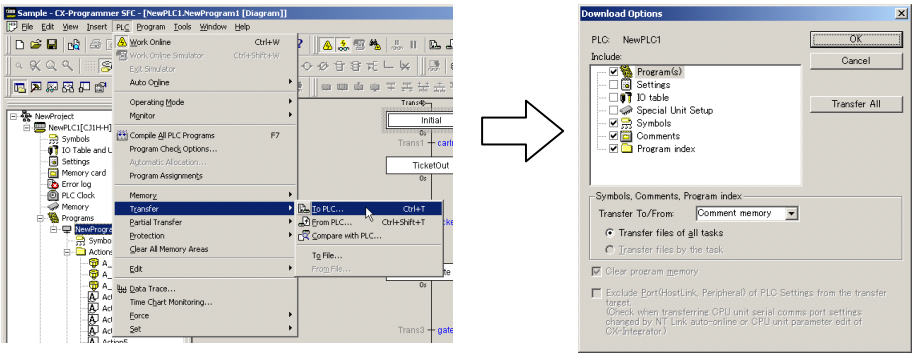
4-1-2 Working Offline

1 Select ***Work Online*** from the PLC menu.
You will be switched to offline state.

4-2 Transferring Programs from Computer to PLC

This section describes how to transfer SFC programs from CX-Programmer to a PLC. After creating a program, it can be transferred to a PLC system by establishing an online connection between CX-Programmer and the PLC system.

1 Select ***Transfer*** - ***To PLC*** from the PLC menu. The Transfer Option [To PLC] dialog is displayed. (*1)



2 Select the items you wish to transfer.
3 Click ***OK***. The transfer is started.

*1: Select ***Partial Transfer*** - ***Task Transfer to PLC*** from the PLC menu to transfer programs on a task unit basis.
Tasks allocated SFC programs and ST programs, however, cannot be partially transferred.

Note: If an SFC program or an ST program is allocated to a task for transfer to PLC using SFC Programming Function, the program cannot be read by CX-Programmer Ver. 7.0 or earlier.

For details on program transfer, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

⚠ **WARNING** Confirm the safety of the destination node before transferring a program or changing contents of the I/O memory area.
An injury may otherwise result.

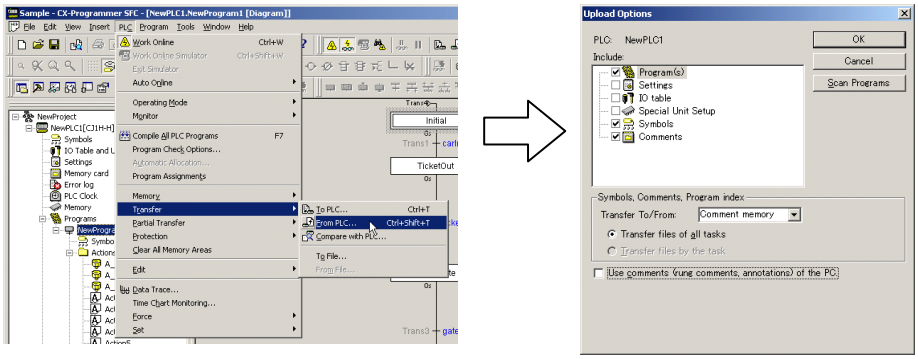
⚠ **Caution**

- Before switching the operating mode of the PLC, verify that there will be no resulting adverse effects on the equipment involved.
- The operation of a user program must be thoroughly tested before use in an actual operation. Be sure to run a program check before transferring the program.
- Programs may be erased if program transfer is performed in the wrong direction. Before proceeding with the transfer, be sure to check direction.

4-3 Transferring Programs from PLC to Computer

This section explains how to transfer SFC programs from a PLC to CX-Programmer.

1 Select ***Transfer*** - ***From PLC*** from the PLC menu. The Transfer Option [From PLC] dialog is displayed. (*1)



2 Select the items you wish to transfer.
3 Click ***OK***. The transfer is started.

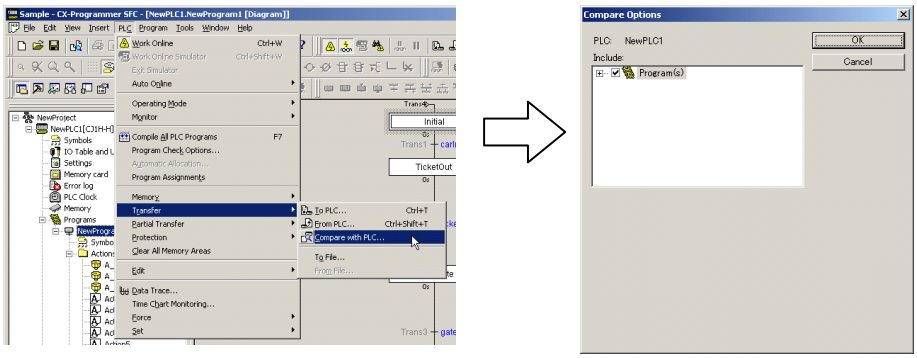
*1: Select ***Partial Transfer*** - ***Task Transfer from PLC*** from the PLC menu to transfer programs on a task unit basis.
Tasks allocated SFC programs and ST programs, however, cannot be partially transferred.

For details on program transfer, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

4-4 Comparing Programs

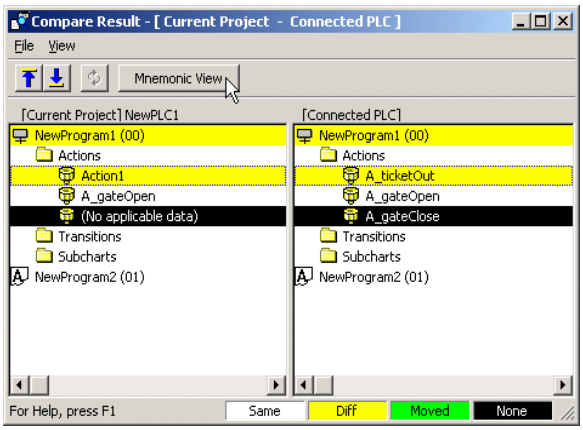
This section describes how to compare the SFC program in a CX-Programmer project with the SFC program in a PLC determine any differences.

1 Select ***Transfer*** - ***Compare with PLC*** from the PLC menu. The Compare Option dialog is displayed. (See note 1.)



2 Select the items you wish to transfer.

3 Click ***OK***. Comparison is started and the comparison results are displayed.



4 To display detailed program comparison results, move the cursor to the desired location and click the **Mnemonic View** Button, or double-click the desired location. (See note 2.)

Note 1: Select ***Partial Transfer*** - ***Compare Task with PLC*** from the PLC menu to compare programs on a task unit basis.
Tasks allocated SFC programs or ST programs, however, cannot be partially transferred.

2: Only different/same results can be displayed for SFC programs. Details are not available.

For details on program comparison, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

4-5 Monitoring

This section describes the basic operations for monitoring programs and PLC status. For program debugging operations, refer to section 5.

4-5-1 Monitoring Start

1 Switch to the online mode as previously described.
2 In the project workspace, select the program to be monitored.

Changing the Operating Mode

To change the PLC operating mode, select a mode as follows.

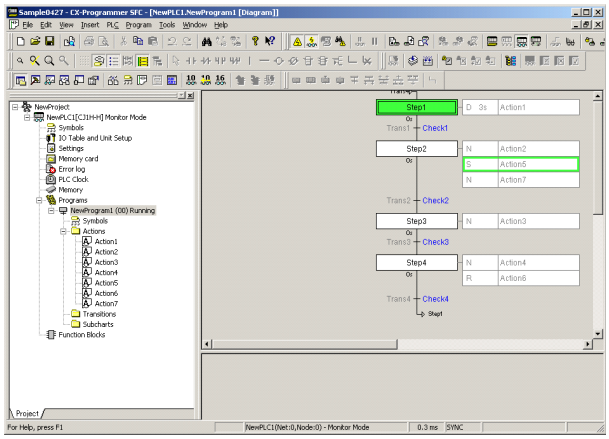
PROGRAM Mode: ***PLC - Operating Mode*** - ***Program***
MONITOR Mode: ***PLC - Operating Mode*** - ***Monitor***
RUN Mode: ***PLC - Operating Mode*** - ***Run***

The functions that can be used in each operating mode are as follows:

Operating mode Name	Program execution	Online editing
PROGRAM	No	OK
Display	OK	OK
RUN	OK	No

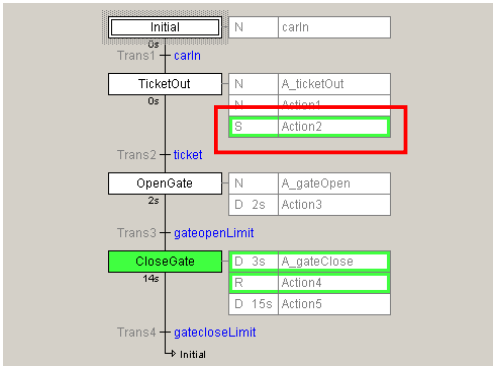
4-5-2 Monitoring SFC Editor

1 Switch to the online mode as previously described.
The monitor screen of the SFC editor is displayed, as shown below. (*1) (*2) (*3)

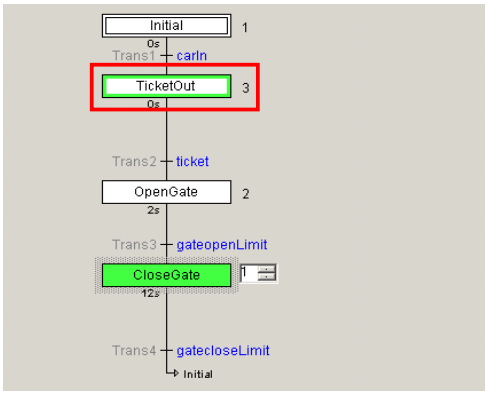


2 To stop monitoring, select ***Monitor*** - ***Monitoring*** from the PLC menu.

*1: While the PLC is running, the active step element and the action element under execution are displayed in yellowish green. The display color can be changed by selecting ***Tools - Options*** - ***Appearance***.
*2: While in the ***MONITOR*** or ***RUN*** operating mode, present values will be updated according to the PLC's operation status. (Present value monitor)
*3: If an action has an S-series AQ (S, SL, SD), its activity status can be monitored, even while the step itself is in the inactive status.



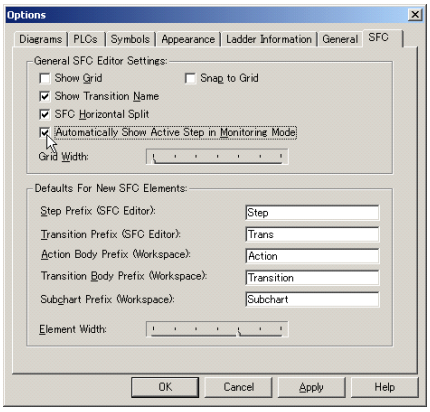
*4: If an action has an S-series AQ (S, SL, SD), its activity status can be monitored, even while the action blocks are hidden.



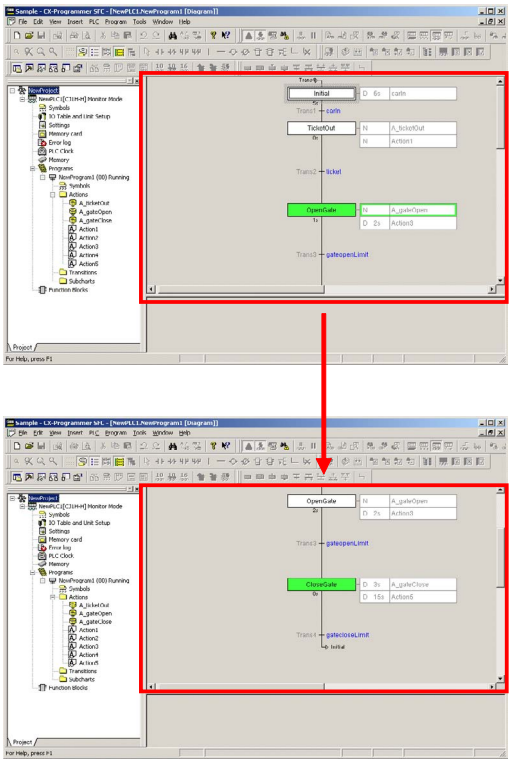
Monitoring the Active Step

The active step can be automatically displayed on the screen.

1 Switch to the online mode as previously described.
2 Select ***Options*** - ***SFC*** from the Tools menu.



3 Check the ***Automatically Show Active Step in Monitoring Mode*** checkbox and click ***OK***. As the active status is transferred for the SFC editor displayed on the screen, the screen will scroll automatically to display the currently active step.

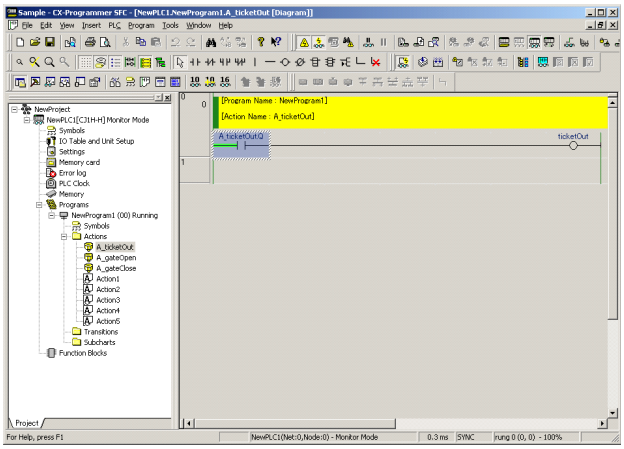


4-5-3 Monitoring Action/Transition Programs

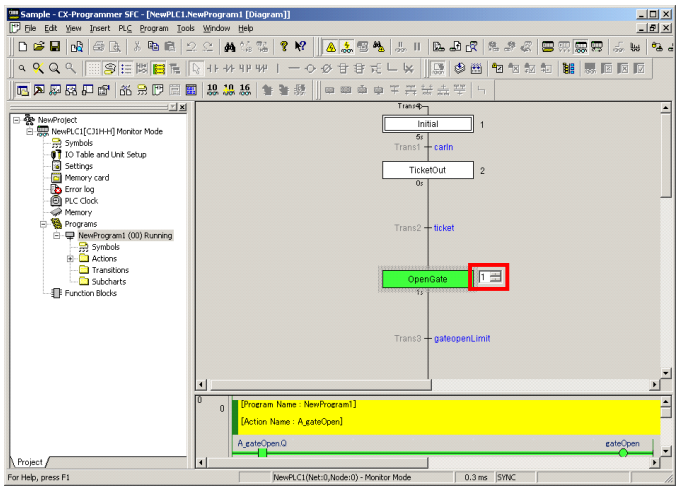
This section describes how to monitor ladder programs for actions and transitions. ST programs cannot be monitored.

Monitoring Ladder Program Execution

1 In the project workspace double-click the action or transition to be monitored to display the editor window while working online. (*1)



2 Clicking the number for a hidden action block in an SFC chart will display a spin box. Change the number to switch the required action program displayed on the program view.



For details, refer to *3-2-3 Adding an Action to a Step (or to the Initial Step).*

SECTION 5
Debug Operations

5-1 Online Editing 104
5-1-1 Online Editing of SFC Charts 104
5-1-2 Online Editing of Actions and Transitions Editing 108
5-1-3 Adding Actions/Transitions 111
5-2 Force Setting/Force-Resetting 113
5-2-1 Force-Setting/Force-Resetting Transitions 113
5-2-2 Force-Setting/Force-Resetting Steps 114
5-3 Set Step Timer Value 115
5-4 Work Online Simulator 116
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5-1 Online Editing

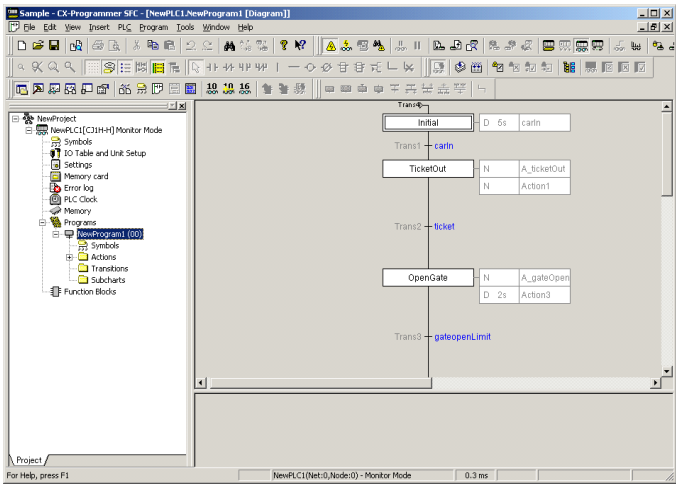
SFC programs can be edited when the PLC (CPU unit) is operating in MONITOR mode. This means that SFC programs can be debugged or edited even on devices for which around-the-clock operation is required.

5-1-1 Online Editing of SFC Charts

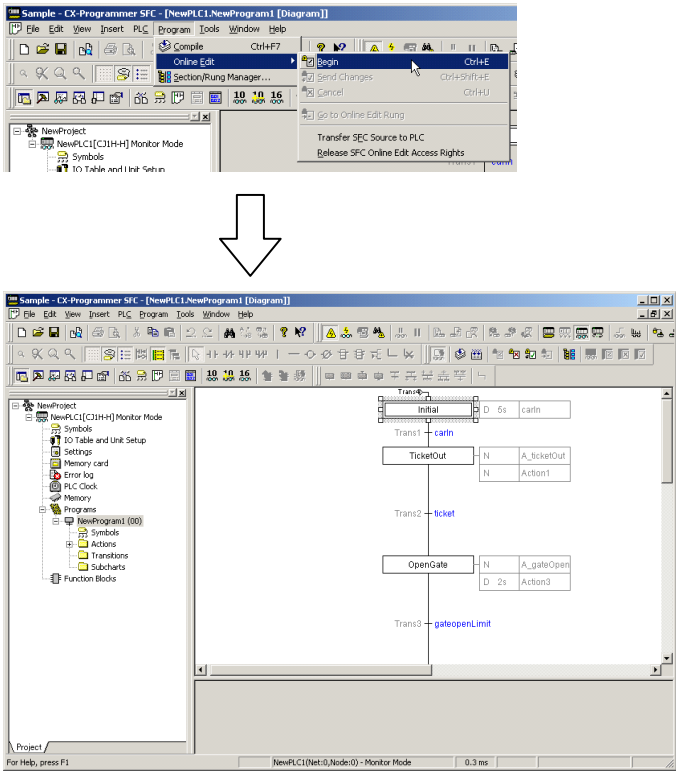
SFC chart can be edited online, as long as the PLC is not in RUN mode.

Starting Online Editing

1 Start monitoring.
2 In the project workspace, select the SFC program to be edited. The SFC program is displayed in the SFC editor.



3 Select ***Program*** - ***Online Edit*** - ***Begin***. The SFC program becomes editable.

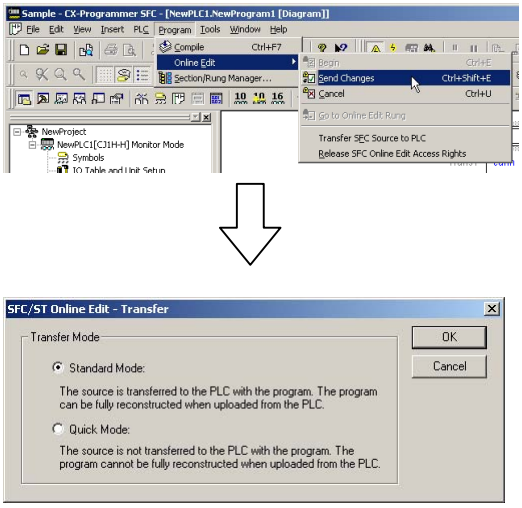


4 Begin editing the SFC program or subcharts. The editing operations are essentially the same as for offline editing.

Note: Refer to *Limitations of Online Editing* on page 108 for precautions that apply during online editing.

Transferring the Changes

1 After editing is complete, select ***Program*** - ***Online Edit*** - ***Send Changes***. The Send Changes dialog is displayed, as shown below.


Sample - CX-Programmer SFC - [NewPLC1.NewProgram1 [Diagram]]
Compile Ctrl+F7
Online Edit
Section/Rung Manager...
Begin Ctrl+E
Send Changes Ctrl+Shift+E
Cancel Ctrl+U
Go to Online Edit Rung
Transfer SFC Source to PLC
Release SFC Online Edit Access Rights
SFC/ST Online Edit - Transfer
Transfer Mode
Standard Mode:
The source is transferred to the PLC with the program. The program can be fully reconstructed when uploaded from the PLC.
Quick Mode:
The source is not transferred to the PLC with the program. The program cannot be fully reconstructed when uploaded from the PLC.
OK
Cancel

2 Select the transfer mode and click ***OK***. The edited SFC program is transferred to the PLC.
For details on the transfer modes, refer to *Transfer Modes* and *Selecting a Transfer Mode* below.

3 When the transfer is complete, the SFC program automatically reverts to the non-editable state. To perform further editing, repeat the online editing procedure from the beginning.

Transfer Modes

Standard Mode

The SFC source code and object code for the SFC program are both transferred to the PLC (CPU Unit).
In “Standard Mode”, transfer may take a little longer to complete, depending on the amount of data. You cannot perform another edit or transfer operation while a transfer is in progress.

Quick Mode

Only the object code for the SFC program is transferred to the PLC (CPU Unit). The SFC source code will not be transferred.
Since only the object codes are transferred, “Quick Mode” transfers are much faster than “Standard Mode” transfers.
After transferring the object codes in "Quick Mode", transfer the SFC source code for the SFC program to the PLC (CPU Unit) when, 1) executing "Transfer SFC Source to PLC" or 2) going offline. After sending changes, a yellow mark will be displayed at the bottom of the screen to indicate that “the SFC source code has not been transferred”. The yellow mark will disappear after the SFC source code has been transferred.

Selecting a Transfer Mode

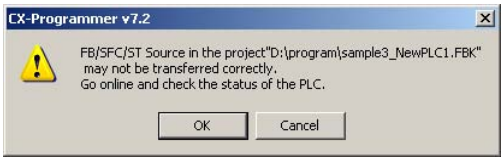
In general, unless online editing is done frequently and continuously, "Standard Mode” should be used. If the transfer takes a long time to complete, try to resolve the situation by increasing the connection speed with the PLC.
Should the transfer time take so long as to interfere with debugging (i.e. when performing frequent and successive online edits while debugging), use “Quick Mode” to transfer, but be fully aware of the “Limitations of Quick Mode (No SFC Source Code Transfer)”, described below.

⚠Caution Limitations of Quick Mode (No SFC Source Code Transfer):
CX-Programmer is not capable of uploading a correct program, including the SFC charts, unless the SFC source code for the SFC program has been transferred. Hence, when working online, if changes made to the SFC program have been transferred in "Quick Mode”, CX-Programmer may become incapable of uploading the program if, before switching to the offline state (i.e. before the SFC source code is transferred), the computer (CX-Programmer) crashes or if the PLC system experiences a power failure.

Should such a situation occur, you may be able to re-transfer the SFC source code by using the following procedure.

Transferring the Source Code from a Backed-up Project

1. Start the CX-Programmer.
2. Transfer the project in Quick Mode before transferring the SFC source code. The following message will be displayed if the transfer fails for a project.



3. Click the **OK** Button. The backed-up project that was transferred with Quick Mode will be started.
4. Connect online to the PLC to which data was previously transferred in Quick Mode. The following message will be displayed.

CX-Programmer v7.2
Check if the backed-up FB/SFC/ST Source can be transferred.
If [No] is selected, the program cannot be transferred from the PLC correctly after going online.
Yes
No

5. Click the **Yes** Button. When not in RUN mode, the project will be compared between the computer and PLC and if it is the same, the SFC source code will be transferred. When in RUN mode, change to a different mode and transfer the SFC source code using the menus.

Transferring the SFC Source Code Manually

1. Start the CX-Programmer and open the project file for which the SFC source code is to be transferred.
2. Connect online to the PLC to which data was previously transferred in Quick Mode. The status bar of the CX-Programmer will flash a yellow message saying that the source code is different.
3. Select ***Project – Online Editing – Transfer SFC/ST Source.*** The source code transfer dialog box will be displayed.
4. Click the **OK** Button.
   The SFC source code, automatically back up onto the computer, will be compared with the object code on the PLC system. If the two codes match, the SFC source code can be transferred.

INFO	Normally, CX-Programmer converts (compiles) the program code (SFC source code) into the code which is executable by the CPU unit (object code) and transfers both of these codes. The CPU unit saves the program's SFC source code and object code onto the user memory area and onto the internal flash memory. CX-Programmer can recover the transferred program by the transfer from the CPU unit, only when both of these codes have been properly saved.

Cancel

1 To discard the changes made to an edited SFC program, select ***Program*** - ***Online Edit*** - ***Cancel***. The edited SFC program will return to the state before the editing, without being transferred to the PLC.

Effect on CPU Unit Operation

Performing online editing in MONITOR mode (i.e. while the CPU unit is in operation) will:

1) Extend the cycle time for the CPU unit by several cycles when the CPU unit program is rewritten; and
2) Further extend the cycle time upon completion of online editing, when the execution results are backed up onto the internal flash memory. (During this time, the BKUP indicator on the front of the CPU unit will be lit, and progress will be displayed by the CX-Programmer.)

Extension of the cycle time by an online edit is as follows.

Maximum Extension of Cycle Time	
1) During Online Edit	2) During Backup
12 ms max.	4% of cycle time

⚠**Caution** When performing online editing in the MONITOR mode, ensure that the cycle time required for the program to be updated does not exceed "Watch Cycle Time" specified in PLC Settings. Otherwise, a cycle time error will occur, and operation of the CPU unit will be stopped. To run the CPU unit again, first switch to the PROGRAM mode, and then switch to the RUN mode or the MONITOR mode.

Limitations of Online Editing

Limitations for online editing are as follows.

- For CS/CJ-series units except for CJ2 CPU Units, SFC programs (including the action programs and transition programs) can be edited online only if they are 4K steps or smaller.
- For CS/CJ-series units except for CJ2 CPU Units, the maximum allowable change in size for a single online edit session is 0.5K.
- After completing online editing, do not turn the PLC power OFF until the CPU unit completes a backup to the internal flash memory (i.e. until the BKUP LED on the front of the CPU unit switches from lit to dimmed).
  Turning the PLC power OFF before the backup is complete (i.e. while the BKUP LED on the front of the CPU unit is still lit) will interrupt the backup, and the program will revert back to the unedited state.
- Function blocks cannot be edited online
  Also, neither function block definitions nor function block instances can be added or deleted by editing online.
- Addresses allocated in steps and transitions during online editing will be initialized when online editing is ended.
- Perform online editing in two steps when adding an action program or transition program to an SFC chart.
  1 First, use online editing to add the new action program or transition program to the SFC program and transfer the data to the PLC.
  2 Perform online editing again to add the action program or transition program created in the first step to the SFC chart.
- Subcharts cannot be edited online.

Precautions on Online Editing

- If an SFC chart is changed using online editing in the same cycle in which step status changes, the final scan and the P0 action of steps that became inactive will not be executed. The P and P1 actions of steps that became active will also not be executed.

5-1-2 Online Editing of Actions and Transitions Editing

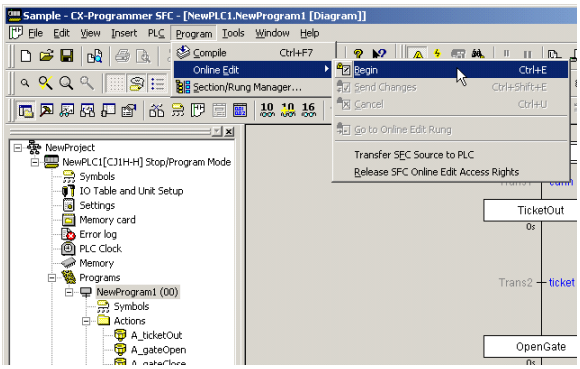
Ladder and structured text programs for actions and transitions can be edited online, as long as the PLC is not in the RUN mode.

Note: When online editing actions/transitions, it is not possible to edit the SFC chart.

Starting Online Editing

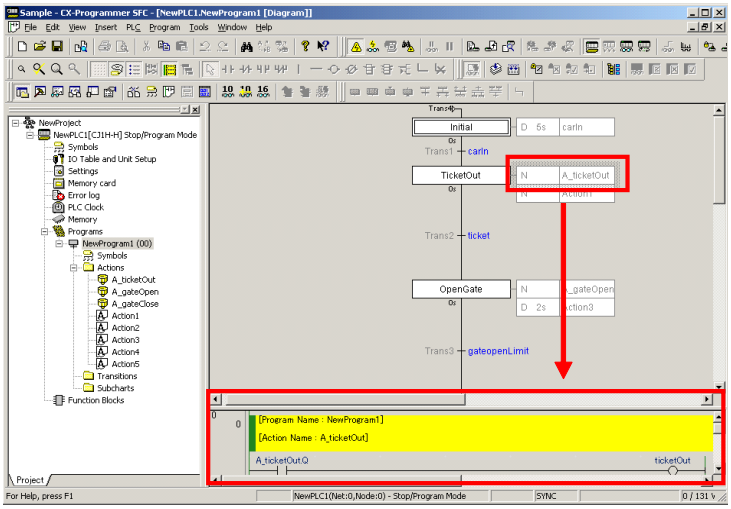
1 Start monitoring.
2 In the project workspace double-click the action or transition to be edited to display the editor window.
3 Select ***Program*** - ***Online Edit*** - ***Begin***. The program becomes editable.

Note: Only one SFC element at a time may be added to the project workspace during an online edit session.



4 Begin editing the program. The editing operations are the same as for offline editing,(*1) (*2)

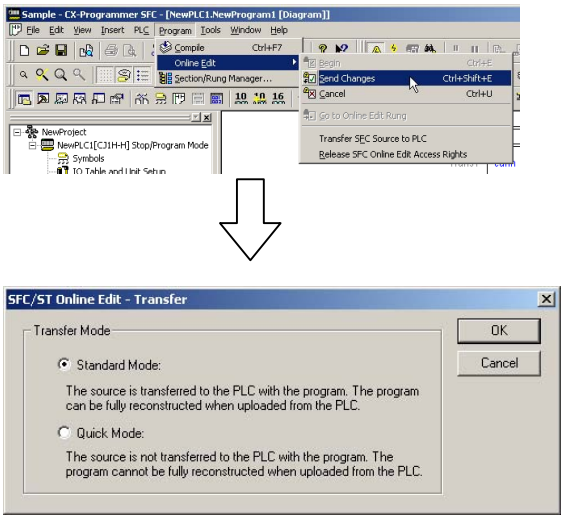
*1: Edit the ladder program in the program view.



*2: For details on editing ladder programs, refer to the *CX-Programmer Operation Manual* (Cat. No. W446).

Transferring the Changes

1 After editing is complete, select ***Program*** - ***Online Edit*** - ***Send Changes***. The Send Changes dialog is displayed, as shown below.


Sample - CX-Programmer SFC - [NewPLC1.NewProgram1 [Diagram]]
File Edit View Insert PLC Program Tools Window Help
Compile Ctrl+F7
Online Edit
Section/Rung Manager...
Begin Ctrl+E
Send Changes Ctrl+Shift+E
Cancel Ctrl+U
Go to Online Edit Rung
Transfer SFC Source to PLC
Release SFC Online Edit Access Rights
NewProject
NewPLC1[CJ1H-H] Stop/Program Mode
Symbols
IO Table and Unit Setup
SFC/ST Online Edit - Transfer
Transfer Mode
Standard Mode:
The source is transferred to the PLC with the program. The program can be fully reconstructed when uploaded from the PLC.
Quick Mode:
The source is not transferred to the PLC with the program. The program cannot be fully reconstructed when uploaded from the PLC.
OK
Cancel

2 Select the transfer mode and click ***OK***. The edited ladder or ST program is transferred to the PLC

3 When the transfer is complete, the ladder or ST program automatically reverts to the non-editable state. To perform further editing, repeat the online editing procedure from the beginning.

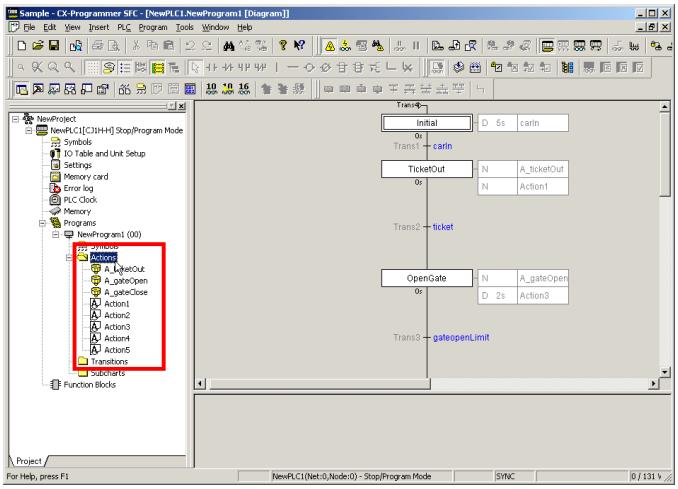
Cancel

1 To discard the changes made to an edited ladder or ST program, select ***Program*** - ***Online Edit*** - ***Cancel***. The edited ladder or ST program will return to the state before the editing, without being transferred to the PLC.

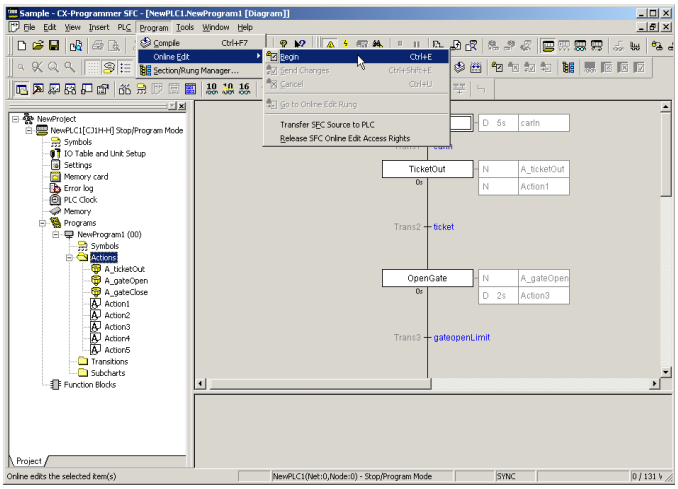
5-1-3 Adding Actions/Transitions

When editing new actions or transitions online, perform the following operation to add an action or transition, and then edit the added action or transition online, using procedure *5-1-1 Online SFC Chart Editing*.

1 In the project workspace, select the folder for the SFC element to be added. Select *Actions* for an action and *Transitions* for a transition.

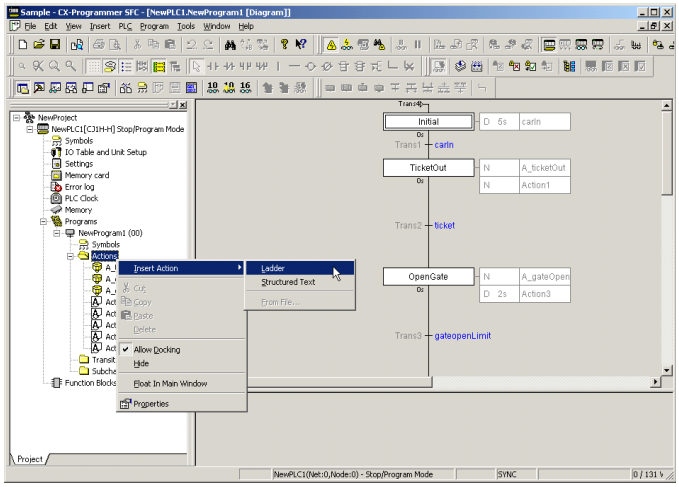


2 With the folder selected, select ***Program*** - ***Online Edit*** - ***Begin***.



You can now add an SFC element of the selected type.

Note: When online editing actions/transitions, it is not possible to edit the SFC chart.



3 The added SFC element can be used for online SFC chart editing.
When SFC elements are added, the changes must be sent to the PLC before online SFC chart editing
For details, refer to *5-1-1 Online SFC Chart Editing*.

Note: Only one SFC element at a time may be added to the project workspace during an online edit session.

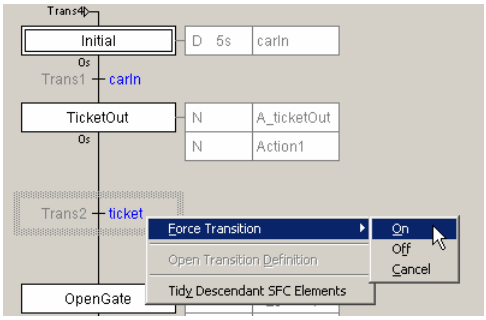
5-2 Force Setting/Force-Resetting

5-2-1 Force-Setting/Force-Resetting Transitions

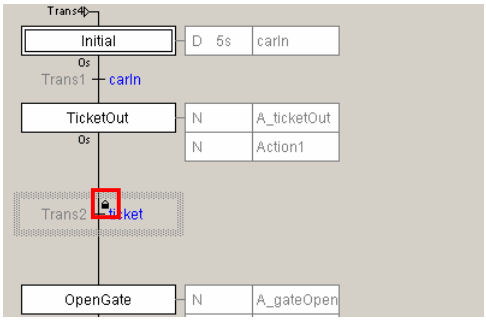
Transitions can be executed or stopped forcibly, by force-setting/force-resetting, as long as the PLC is not in the RUN mode.
Force-setting turns a transition flag ON, and force-resetting turns a transition flag OFF. The ON/OFF status will be maintained until the forced status is cleared, or until another force-set/force-reset operation is performed. It will not be changed by external inputs or by program execution results.

Force-Setting/Force-Resetting a Transition

1 In the SFC editor, select and right-click the transition to force-set/force-reset.
2 Select ***Force Transition*** - ***On*** or ***Force Transition*** - ***Off*** from the pop-up menu. The selected transition will be force-set/force-reset.



The transition will be marked to indicate that it has been force-set/force-reset, as shown below.



Clearing the Forced Status of a Transition

1 In the SFC editor, select and right-click the transition for which the force-set/force-reset is to be cleared.
2 Select ***Force Step*** – ***Cancel*** from the pop-up menu. The force-set/force-reset status is cleared for the selected transition.

Clearing All Forced Statuses

1 Select ***Force*** - ***Cancel All Forces*** from the PLC menu. The force-set/force-reset status is cleared for all I/O memory areas, including transitions.

Force-resetting Transitions

If the Transition Flag following a step that became active when step status changes is force-set, the step status will immediately change again and the actions will not be executed. Unless you want to force the status of the previous step to change when you force-set a Transition Flag, always cancel the force-set status in advance.

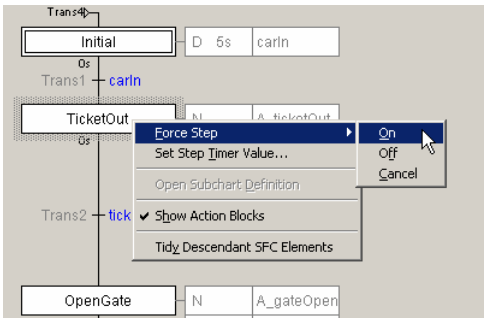
5-2-2 Force-Setting/Force-Resetting Steps

Steps can be activated or deactivated forcibly by force-setting/force-resetting, as long as the PLC is not in the RUN mode.
Force-setting activates a step, and force-resetting deactivates a step.
The activity status will be maintained until the forced status is cleared, or until another force-set/force-reset operation is performed. It will not be changed by external inputs or by program execution results.
When a step has been force-set, the Actions associated with that step will become active. When a step has been force-reset, the Actions associated with that step will become inactive.

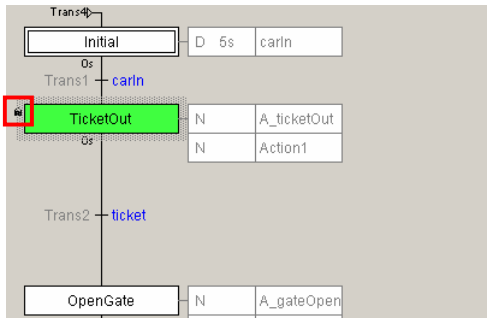
Note: The behavior of Action Qualifiers is the same as if the step had become active under normal conditions.

Force-Setting/Force-Resetting a Step

1 On the SFC editor, select and right-click the step to force-set/force-reset.
2 Select ***Force Transition*** - ***On*** or ***Force Transition*** - ***Off*** from the pop-up menu. The selected step will be force-set/force-reset.



The step will be marked to indicate that it has been force-set/force-reset, as shown below.



Clearing the Forced Status of a Step

1 In the SFC editor, select and right-click the Step for which the force-set/force-reset is to be cleared.
2 Select ***Force Step*** – ***Cancel*** from the pop-up menu. The force-set/force-reset status is cleared for the selected step.

Clearing All Forced Statuses

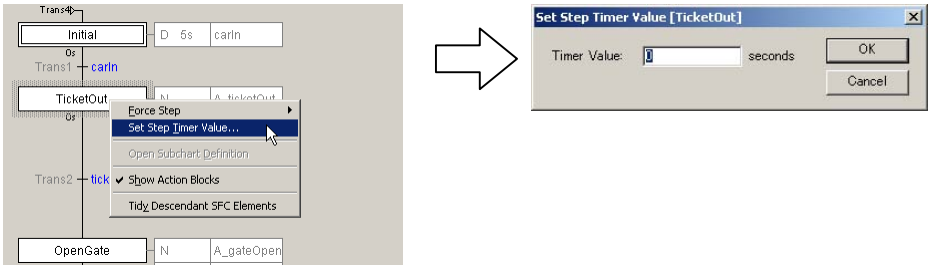
1 Select ***Force*** - ***Cancel All Forces*** from the PLC menu. The force-set/force-reset status is cleared for all I/O memory areas, including steps.

5-3 Set Step Timer Value

Present value of a step timer for the active step of the SFC program can be changed, as long as the PLC is not in the RUN mode.

Changing a Step Timer Present Value

1 From the SFC editor, select and right-click the step for which the step timer present value is to be changed.
2 Select ***Set Step Timer Value*** from the pop-up menu.
The Set Step Timer Value dialog is displayed.



3 On the Set Step Timer Value dialog, input the desired timer value (0 – 65535 seconds or 0 – 6553.5 seconds) and click ***OK***. The new value is reflected on the PLC.

5-4 Work Online Simulator

The PLC Simulator can be used to check the operation of programs without transferring them to an actual PLC.

5-4-1 Starting and Ending the Simulator

Starting the Simulator

1. Start the CX-Programmer.
2. Read a program that was previously created.
3. Select ***Work Online Simulator*** from the Simulation Menu.
   The Simulator and CX-Programmer will be connected online and the Download Options Dialog Box will be displayed.
4. Click the **OK** Button. The program will be downloaded to the Simulator.
   ”Download successful” will be displayed when the data has been downloaded.
5. Click the **OK** Button. The online connection will be broken.
6. Select ***Operating Mode – Monitor*** from the PLC Menu to switch to MONITOR mode.

Ending the Simulator

1. Select ***Work Online Simulator*** from the Simulation Menu.
   The online connection between the Simulator and CX-Programmer will be broken
2. Select ***Exit Simulator*** from the Simulation Menu. The Simulator will be ended.

Limitations

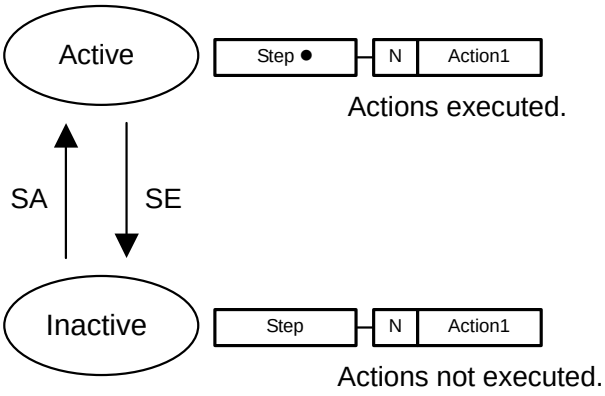
The debugging functions of the Simulator, such as step execution and breakpoints, cannot be used for SFC charts, ladder/ST action programs, ladder/ST action programs, or subcharts.
In addition, online editing is disabled while PLC simulator is used.

Appendix A
Specifications for Step Control Instructions

Step Control Instructions are used to control the active status of steps and subcharts in SFC programs. There are two Step Control Instructions.

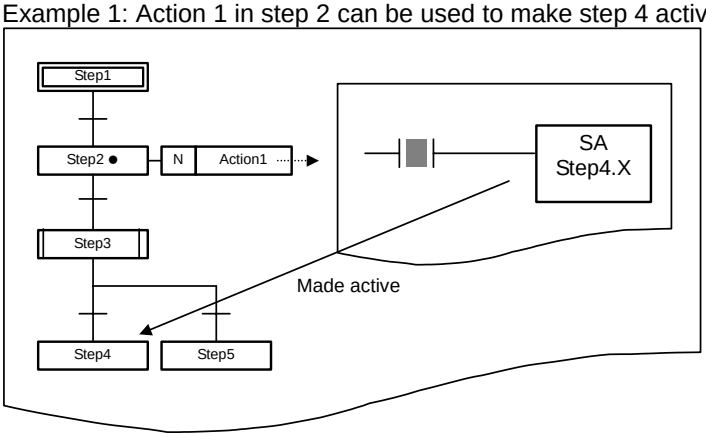
Instruction	Mnemonic	Outline
STEP ACTIVATION	SA	Makes the specified step or subchart active to start execution of the actions.
STEP DEACTIVATION	SE	Makes the specified step of subchart inactive to end execution of the actions.

Status is changed as follows by the Step Control Instructions.

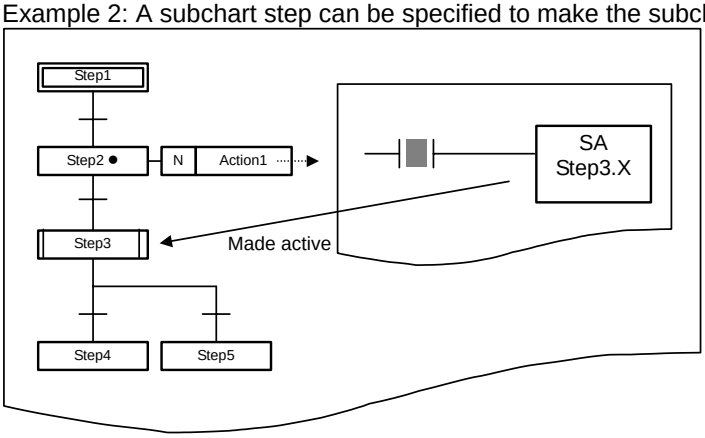


Note: The active steps is indicated by a solid circle (●).

Example 1: Action 1 in step 2 can be used to make step 4 active.



Example 2: A subchart step can be specified to make the subchart active.



Refer to *2-3-1 Steps* for information on using the Step Control Instructions (SA/SE).

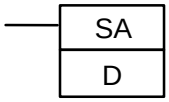
A-1 STEP ACTIVATE (SA) and STEP DEACTIVATE (SE)

SA Instruction

Outline

Changes a step used in an SFC chart from inactive to active status.

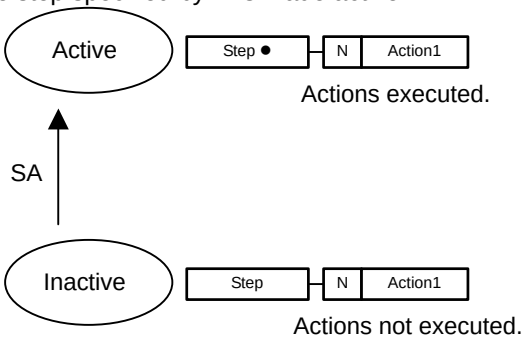
Symbol



D: Step Flag

Description

The step specified by D is made active.



Variations

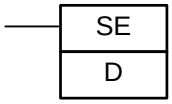
Variations	Executed Each Cycle for ON Condition	SA
	Executed Once for Upward Differentiation	@SA
Immediate Refreshing Specification		None

SE Instruction

Outline

Changes a step used in an SFC chart from active to inactive status.

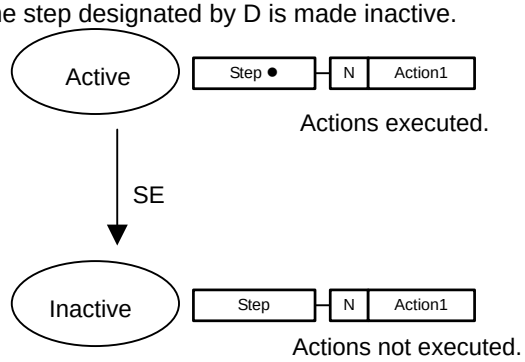
Symbol



D: Step Flag

Description

The step designated by D is made inactive.



Variations

Variations	Executed Each Cycle for ON Condition	SE
	Executed Once for Upward Differentiation	@SE
Immediate Refreshing Specification		None

Applicable Program Areas

SA/SE

Area	Function block definitions	Block program areas	Step program areas	Sub-routines	Interrupt task programs
Usage	OK	OK	OK	OK	OK

Condition Flags

Name	Label	Status
Error Flag	P_ER	OFF

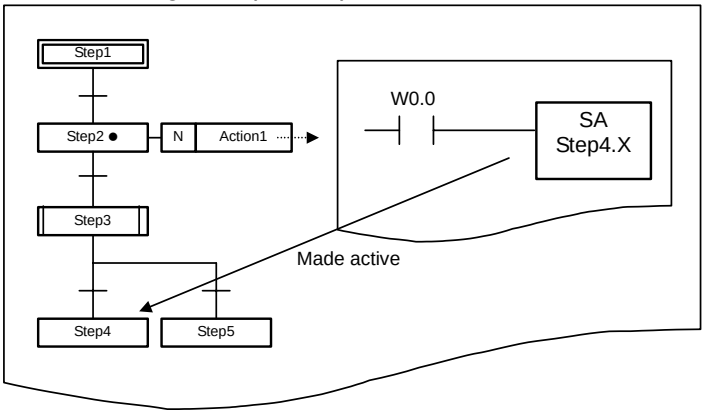
Note:

- Designate Step Flags in the form *step_name*.X. Refer to *2-3-1 Steps* for details.
- Steps within subcharts cannot be specified.
- These instructions cannot be input or displayed on a Programming Console. "?" will be displayed.

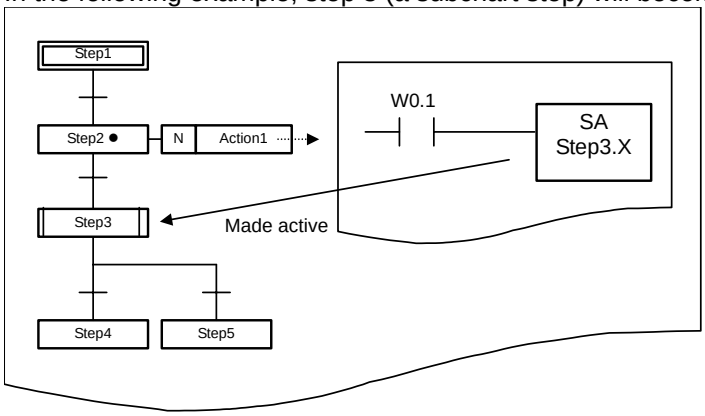
Operation

Examples

In the following example, step 4 will become active when W0.0 turns ON.



In the following example, step 3 (a subchart step) will become active when W0.1 turns ON.



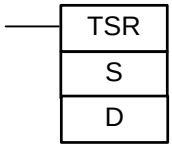
A-2 READ SET TIMER (TSR)/SET STEP TIMER (TSW)

TSR Instruction

Outline

Read the present value of the Step Timer.

Symbol



S: Step Timer
D: First word to store the Step Timer's present value

Description

The present value of the Step Time specified by S is stored starting at D.

Variations

Variations	Executed Each Cycle for ON Condition	TSR
	Executed Once for Upward Differentiation	@TSR
Immediate Refreshing Specification		None

Applicable Program Areas

Area	Function block definitions	Block program areas	Step program areas	Subroutines	Interrupt task programs
Usage	OK	OK	OK	OK	OK

Operand Specifications

Area	S	D
CIO Area (e.g., I/O bits)	Step Timer	CIO 0000 to CIO 6143
Work Area		W000 to W511
Holding Bit Area		H000 to H511
Auxiliary Bit Area		A448 to A959
DM Area		D00000 to D32767
EM Area		E00000 to E32767 En_00000 to En_32767 (n = 0 to C)
Constants		#0000 to #FFFF (binary data)

Condition Flags

Name	Label	Status
Error Flag	P_ER	OFF

Note:

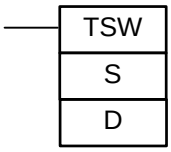
- Specify Step Timers in the form *step_name*.T. Refer to *2-3-1 Steps for details*.
- Refer to *2-3-1 Steps* for information on using this instruction.
- This instruction cannot be input or displayed on a Programming Console. "?" will be displayed.

TSW Instruction

Outline

Changes the present value of the Step Timer.

Symbol



S: First word holding the Step Timer's new present value
D: Step Timer

Description

The present value of the Step Timer specified by S is changed to the value specified starting at D.

Variations

Variations	Executed Each Cycle for ON Condition	TSW
	Executed Once for Upward Differentiation	@TSW
Immediate Refreshing Specification		None

Applicable Program Areas

Area	Function block definitions	Block program areas	Step program areas	Subroutines	Interrupt task programs
Usage	OK	OK	OK	OK	OK

Operand Specifications

Area	S	D
CIO Area (e.g., I/O bits)	CIO 0000 to CIO 6142	Step Timer
Work Area	W000 to W510	
Holding Bit Area	H000 to H510	
Auxiliary Bit Area	A448 to A958	
DM Area	D00000 to D32766	
EM Area	E00000 to E32766 En_00000 to En_32766 (n = 0 to C)	
Constants	&0 to &65535	

Condition Flags

Name	Label	Status
Error Flag	P_ER	OFF

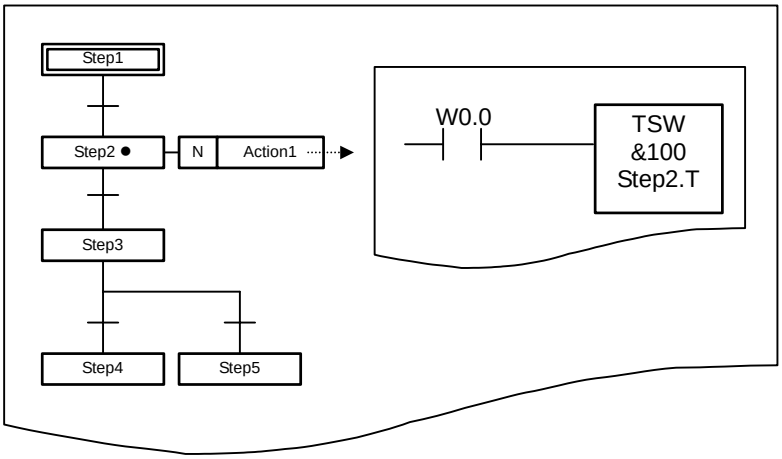
Note:

- Specify Step Timers in the form *step_name*.T. Refer to *2-3-1 Steps* for details.
- Refer to *2-3-1 Steps* for information on using this instruction.
- This instruction cannot be input or displayed on a Programming Console. "?" will be displayed.

Operation

Example

In the following example, the present value of the Step Timer for step 2 is changed to 100 when W0.0 turns ON.



The active steps is indicated by a solid circle (●).

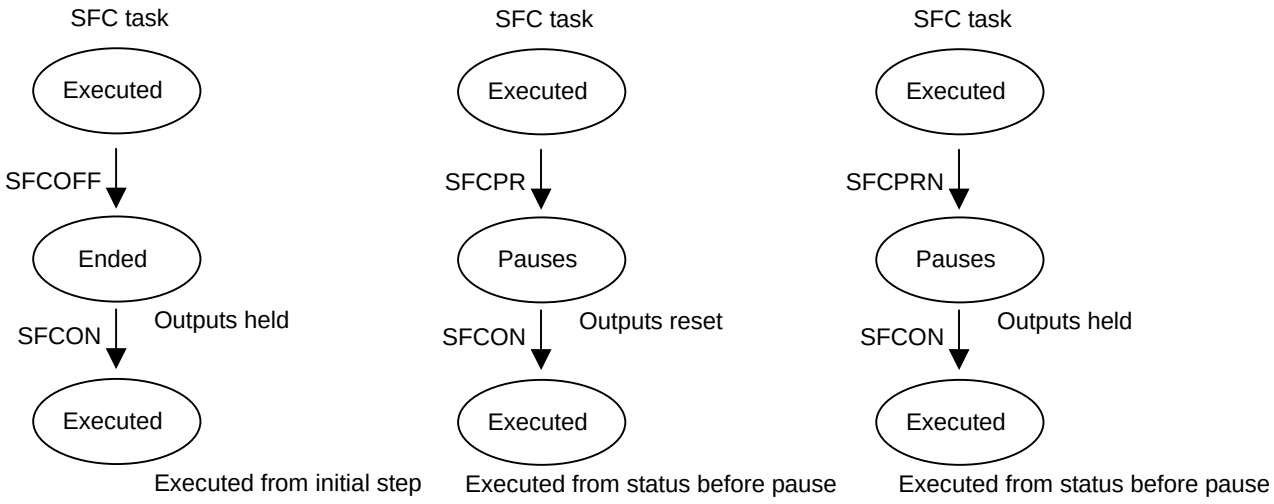
Appendix B

SFC Task Control Instruction Specifications

The following type of control can be achieved by using the SFC Task Control Instructions

- Ending SFC task execution using the SFCOFF instruction
- Pausing SFC task execution and resetting outputs using the SFCPR instruction
- Pausing SFC task execution and holding outputs using the SFCPRN instruction
- Restarting execution of SFC tasks that have been ended or paused using the SFCON instruction

SFC OFF: SFCOFF	Ends execution of an SFC task. The outputs from any actions that are being executed in the task that is ended will be held and processing will be ended. When execution is started again with the SFCON instruction, it will start from the initial step.
SFC PAUSE WITH RESET: SFCPR	All outputs in the task that is paused will be reset and processing will be paused. Be careful when using this command if any outputs that will be reset are used in other tasks. When execution is started again with the SFCON instruction, it will start from the step that was active before the task was paused. The Step Time for the paused step will continue to operate even while the step is paused.
SFC PAUSE WITH NO RESET: SFCPRN	Pauses execution of an SFC task. The outputs from any actions that are being executed in the task that is paused will be held and processing will be paused. When execution is started again with the SFCON instruction, it will start from the step that was active before the task was paused. The Step Time for the paused step will continue to operate even while the step is paused.
SFC ON: SFCON	Restarts execution of an SFC task that was ended or paused using one of the other SFC Task Control Instructions.



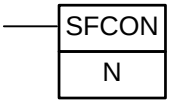
B-1 SFC ON (SFCON)/SFC OFF (SFCOFF)

SFCON Instruction

Outline

Restarts execution of an SFC task that was ended or paused using one of the other SFC Task Control Instructions.

Symbol



N: SFC task number

Operands

Cyclic Task

For CJ2

N: &0 to &128 (Correspond to cyclic tasks 0 to 128.)

For other models

N: &0 to &31 (Correspond to cyclic tasks 0 to 31.)

Description

The SFC task specified by N is started.

If an ended task is started, it is executed from the initial step. If a paused task is started, it is executed from the status that existed before it was paused.

Variations

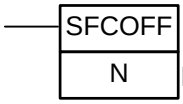
Variations	Executed Each Cycle for ON Condition	SFCON
	Executed Once for Upward Differentiation	None
Immediate Refreshing Specification		None

SFCOFF Instruction

Outline

Ends execution of an SFC task. The status of all outputs is held. When execution of the SFC task is restarted, it is executed from the initial step.

Symbol



N: SFC task number

Operands

Cyclic Task

For CJ2

N: &0 to &128 (Correspond to cyclic tasks 0 to 128.)

For other models

N: &0 to &31 (Correspond to cyclic tasks 0 to 31.)

Description

The SFC task specified by N is ended.

The status of all outputs is held.

When execution is restarted with the SFCON instruction, the task is executed from the initial step.

Variations

Variations	Executed Each Cycle for ON Condition	SFCOFF
	Executed Once for Upward Differentiation	None
Immediate Refreshing Specification		None

Applicable Program Areas

SFCON/SFCOFF

Area	Function block definitions	Block program areas	Step program areas	Sub-routines	Interrupt task programs
Usage	OK	OK	OK	OK	OK

Operand Data

SFCON/SFCOFF

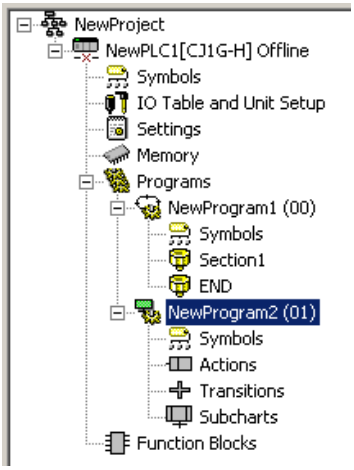
Task name		Operand
Cyclic tasks	0 to 128 (for CJ2)	&0 to &128
	0 to 31 (for other models)	&0 to &31
Extra task 0 (interrupt task 0)		&8000
Extra task 1 (interrupt task 1)		&8001
….		…
Extra task 255 (interrupt task 255)		&8255

Condition Flags

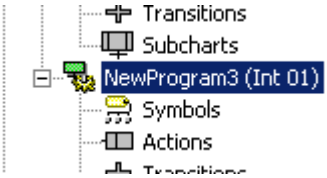
Name	Label	Status
Error Flag	P_ER	OFF

Note:

- Specify the number displayed to the right of the SFC program in the workspace for the SFC task number, as shown below.



As shown below, SFC programs can be created in interrupt tasks and executed as extra tasks. Refer to the *SYSMAC CS/CJ Series Programmable Controllers Programming Manual* (Cat. No. W394) for information on extra tasks.



When using an extra task, specify the SFC task number as shown above for the operand data. For the program shown above for extra task 1 (interrupt task 1), the SFC task number specification would be as follows:

- These instructions cannot be used for the task in which they are programmed. For example, if the instruction is in cyclic task 0 (task number 0), a task number of 0 cannot be specified.
- This instruction cannot be input or displayed on a Programming Console. "?" will be displayed.

Precautions on Using SFCPR

Do not execute the SFCPR instruction for an SFC task that has been ended (see note). Even if the SFCPR instruction is executed for an SFC task that has been ended, the outputs will be reset and the task will not be started. If this happens, you can executed SFCON again to start the task.

Note:

Use the Task Flag to prevent the SFCPR instruction from being executed for an SFC task that has been ended. This is not possible, however, when using an SFC program in an extra task.

- If the SCFPR instruction is executed for a step for which status has changed in the same cycle, the outputs will be reset. This means that the final scan and the P0 action in steps that became inactive will not be executed.
- If the SCFPR instruction is executed for a step for which status has changed in the same cycle and then the SFCON instruction is executed, the SFC task will be started, but the P and P1 actions in steps that became active will not be executed.

Precautions on Using SFCPR/SFCPRN

- The step timers will continue to operate for steps paused with the SFCPR or SFCPRN instruction. The displayed time, however, will not change.
- Step timers may not operate correctly when the SFCPR or SFCPRN instruction is used.

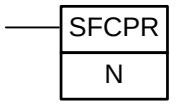
B-2 SFC PAUSE WITH RESET (SFCPR)/SFC PAUSE NO WITH RESET(SFCPRN)

SFCPR Instruction

Outline

Pauses execution of an SFC task. The status of all outputs is reset. When execution of a paused task is restarted, execution will start from the step that was active when the task was paused.

Symbol



N: SFC task number

Operands

Cyclic Task

For CJ2

N: &0 to &128 (Correspond to cyclic tasks 0 to 128.)

For other models

N: &0 to &31 (Correspond to cyclic tasks 0 to 31.)

Description

Execution of the SFC task specified by N is paused.

All outputs from the paused task are reset.

When the paused task is restarted with the SFCON instruction, it is executed from the status that existed before it was paused.

Variations

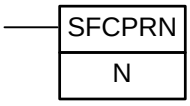
Variations	Executed Each Cycle for ON Condition	SFCPR
	Executed Once for Upward Differentiation	None
Immediate Refreshing Specification		None

SFCPRN Instruction

Outline

Pauses execution of an SFC task. The status of all outputs is held. When execution of a paused task is restarted, execution will start from the step that was active when the task was paused.

Symbol



N: SFC task number

Operands

Cyclic Task

For CJ2

N: &0 to &128 (Correspond to cyclic tasks 0 to 128.)

For other models

N: &0 to &31 (Correspond to cyclic tasks 0 to 31.)

Description

Execution of the SFC task specified by N is paused.

All outputs from the paused task are held.

When the paused task is restarted with the SFCON instruction, it is executed from the status that existed before it was paused.

Variations

Variations	Executed Each Cycle for ON Condition	SFCPRN
	Executed Once for Upward Differentiation	None
Immediate Refreshing Specification		None

Applicable Program Areas

SFCPR/SFCPRN

Area	Function block definitions	Block program areas	Step program areas	Subroutines	Interrupt task programs
Usage	OK	OK	OK	OK	OK

Operand Data

SFCPR/SFCPRN

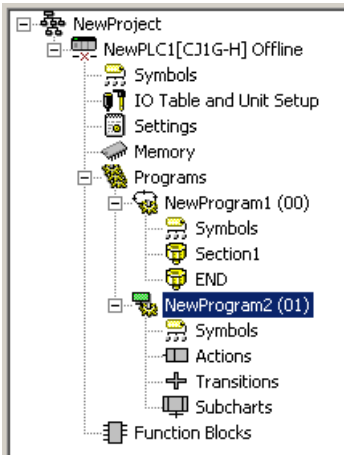
Task name		Operand
Cyclic tasks	0 to 128 (for CJ2)	&0 to &128
	0 to 31 (for other models)	&0 to &31
Extra task 0 (interrupt task 0)		&8000
Extra task 1 (interrupt task 1)		&8001
….		…
Extra task 255 (interrupt task 255)		&8255

Condition Flags

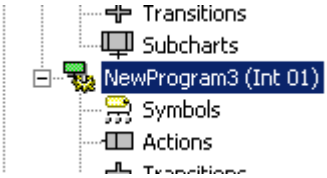
Name	Label	Status
Error Flag	P_ER	OFF

Note:

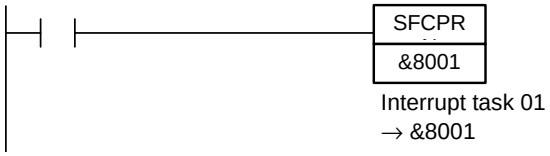
Specify the number displayed to the right of the SFC program in the workspace for the SFC task number, as shown below.



As shown below, SFC programs can be created in interrupt tasks and executed as extra tasks. Refer to the *SYSMAC CJ Series CJ2 Unit Software User's Manual* (Cat. No. W473) and the *SYSMAC CS/CJ Series Programmable Controllers Programming Manual* (Cat. No. W394) for information on extra tasks.



When using an extra task, specify the SFC task number as shown above for the operand data. For the program shown above for extra task 1 (interrupt task 1), the SFC task number specification would be as follows:



- These instructions cannot be used for the task in which they are programmed. For example, if the instruction is in cyclic task 0 (task number 0), a task number of 0 cannot be specified.
- This instruction cannot be input or displayed on a Programming Console. "?" will be displayed.

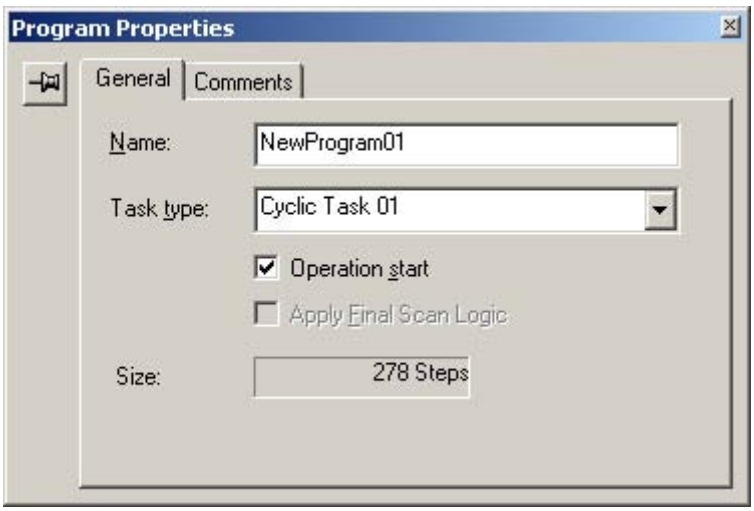
Appendix C

SFC Program Size and Execution Time

This section describes how to check the size and execution time of the SFC program object code.

C-1 SFC Program Object Code Size

The SFC program capacity can be checked using CX-Programmer.
Right-click an SFC program item in the project workspace, and select ***Properties*** from the pop-up menu. The size of the SFC chart is shown on the General tab of the displayed Program Properties Dialog Box: Neither the action program size nor the transition program size is not included.



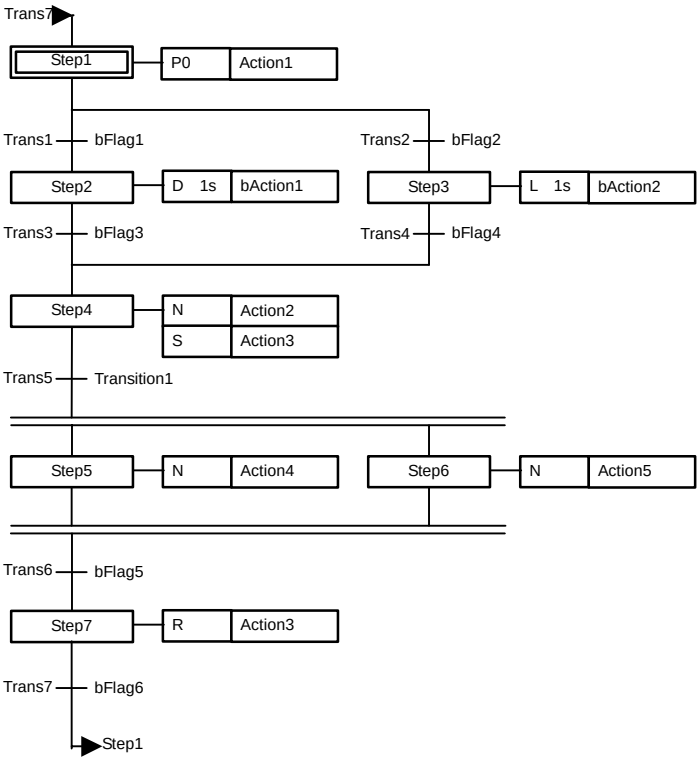
The following table shows the standard program size of each element:

		Program Size (Unit: Step)
Task		60 to 90
Step		10 to 20
Action	Boolean	4 to 40
	Ladder/ST program	9 to 60
Transition	Boolean	7 to 20
	Ladder/ST program	10 to 30
	ST equation	Depending on the conditional equation
Subchart		15 to 30

Note The program size varies depending on the divergence/convergence method or the combination of AQ types.

Example of SFC Program Size

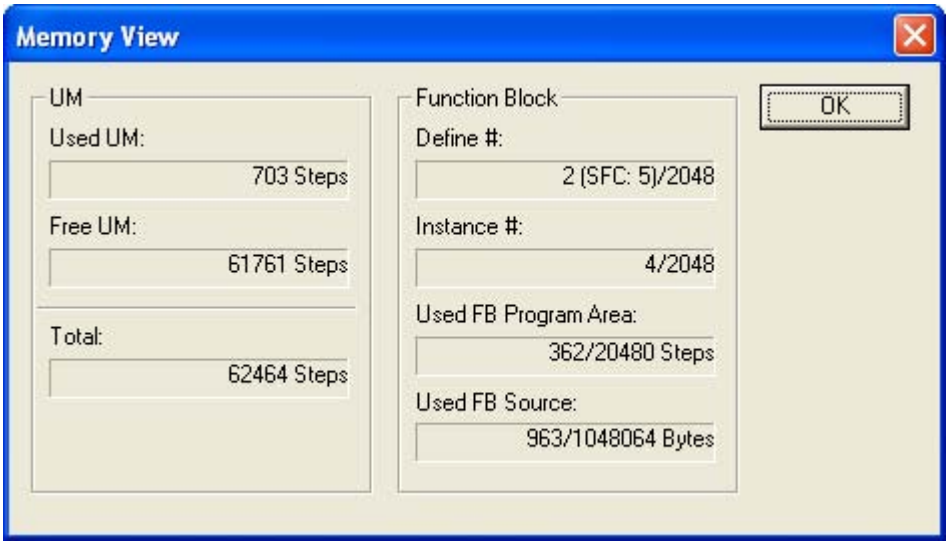
The SFC program size shown below is about 370 steps, including neither the action program size nor the transition program size.



Total SFC Program Usage

The total number of action programs, transition programs, and sub-charts used in SFC programs is displayed in the following Memory View Dialog Box.

1. Select ***Memory View*** from the View Menu.
Example: CJ2M-CPU35



Function Block Area:

Define #: The number of function blocks that are defined and the number of action programs, transition programs, and sub-charts used in SFC programs

Note: The number of action programs, transition programs, and sub-charts used in SFC programs is displayed in parentheses (SFC: xx) if one or more SFC programs is used.

C-2 SFC Program Execution Time

The SFC program execution time varies depending on the following:
- CPU Unit model
- Active/inactive status of the steps
- Combination of AQ types of the actions
- Areas specified in the Function Block/SFC Memory Allocation Dialog Box.

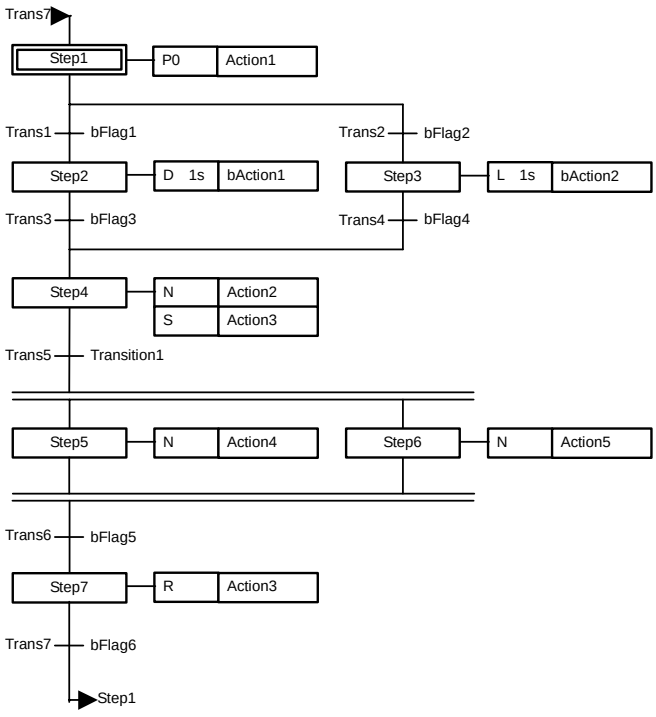
The following table shows the standard execution time of each element:

(Unit: Micro second)

Element		Element status	PLC Model					
			CJ2H	CJ2M	CJ1-R	CJ1H	CJ1G	CJ1M
Task			0.3 to 10	0.7 to 15	0.4 to 15	0.4 to 15	0.7 to 15	0.9 to 20
Step		Active	5 to 10	5 to 8	7 to 12	7 to 12	7 to 12	10 to 17
		Inactive	0.2	0.4	0.3	0.3	0.4	0.5
Action	Boolean	Executed	0.1 to 12	0.2 to 9	0.1 to 12	0.1 to 12	0.2 to 13	0.2 to 18
		Not executed	0.1 to 0.7	0.2 to 1.3	0.1 to 0.7	0.1 to 0.7	0.2 to 1.3	0.2 to 1.6
	Ladder/ST program	Executed	0.4 to 13	1.6 to 10	0.7 to 13	0.7 to 13	1.6 to 14	1.7 to 20
		Not executed	0.3 to 1	0.5 to 1.8	0.2 to 0.8	0.3 to 1	0.5 to 2	0.6 to 2.5
Transition	Boolean	Executed	0.3	0.4	0.2	0.3	0.4	0.6
		Not executed	0.2	0.3	0.1	0.2	0.3	0.4
	Ladder/ST program	Executed	0.6	1.2	0.5	0.6	1.3	1.6
		Not executed	0.2	0.3	0.1	0.2	0.3	0.4
Subchart		Executed	0.6	1.3	0.6	0.7	1.3	1.7
		Not executed	0.3	0.6	0.3	0.3	0.6	0.8

Example of SFC Program Execution Time

When CJ2H-CPU68-EIP is used and Step 1 is active in the SFC program shown below, the execution time of the SFC program is about 13 μ seconds, including neither the action program size nor the transition program size.



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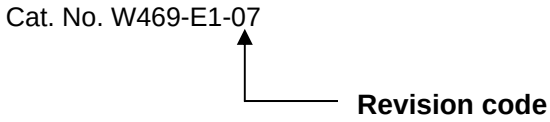
Revision History

A manual revision code appears as a suffix to the catalog number on the front cover of the manual.



The following table outlines the changes made to the manual during each revision. Page numbers refer to the previous version.

Revision code	Date	Revised content
01	June 2007	Original production
02	August 2007	**Pages 104 to 106, 108:** “Or/and subchart” or “or/and subcharts” removed. **Page 113:** Information added on force-setting transitions. **Page 125:** Precautions added.
03	June 2008	Added upgrade information of CX-Programmer
04	February 2009	Added upgrade information of CX-Programmer
05	December 2009	Added upgrade information of CX-Programmer
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